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# THE AMERICAN JOURNAL OF ROENTGENOLOGY RADIUM THERAPY

AND

### NUCLEAR MEDICINE

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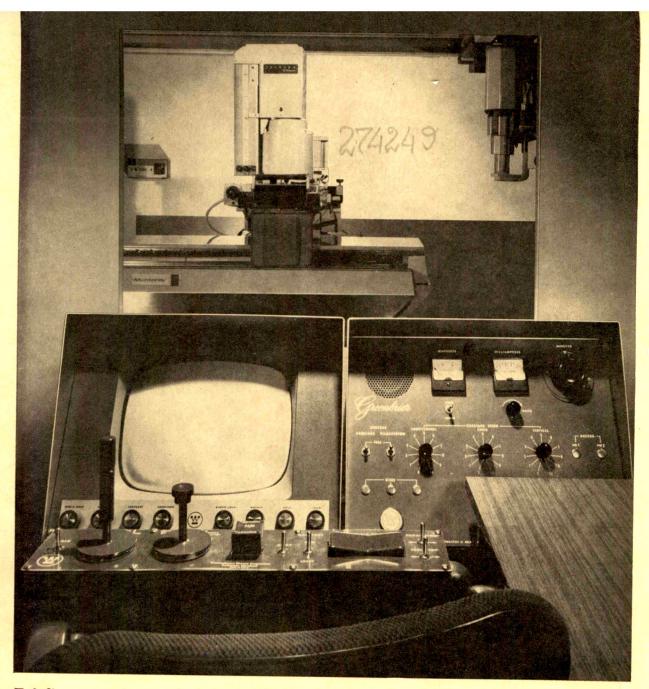
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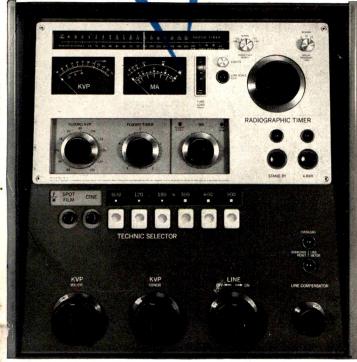
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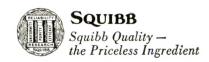
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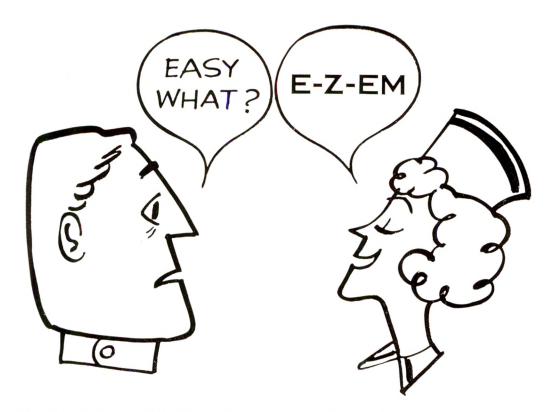
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References: (1) Cohn, E. M.: Am. J. Gastroenterol. 35:115 (Feb.) 1961. (2) Jones, M. D.; Sakai, H.; and Rogerson, A. G.: J. Pediat. 53:172 (Aug.) 1958. (3) Machella, T. E.: Gastroenterology 34:1050 (June) 1958. (4) Orloff, T. L.: Am. J. Roentgenol. 80:618 (Oct.) 1958. (5) Johnson, G., Jr.; Pearce, C.; and Glenn, F.: Ann. Surg. 152:91 (July) 1960. (6) McClenahan, J. L.: Pennsylvania M. J. 62:188 (Feb.) 1959. CHOLOGRAFIN: AND COUGRAFIN: ARE SQUIBB TRADEMARKS.





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Reference: Steinbach, H. L., and Burhenne, H. J.: Performing the Barium Enema: Equipment, Preparation, and Contrast Medium. Am. J. Roentgenol. 87:644, 1962.

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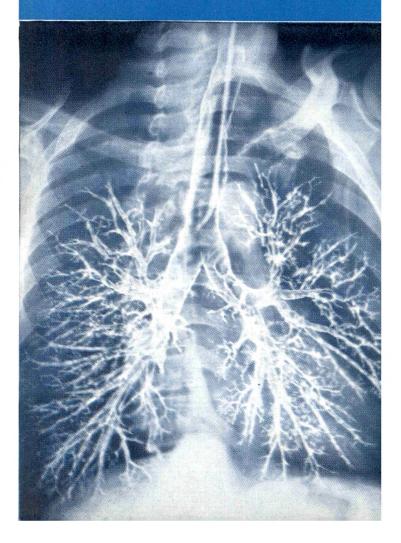
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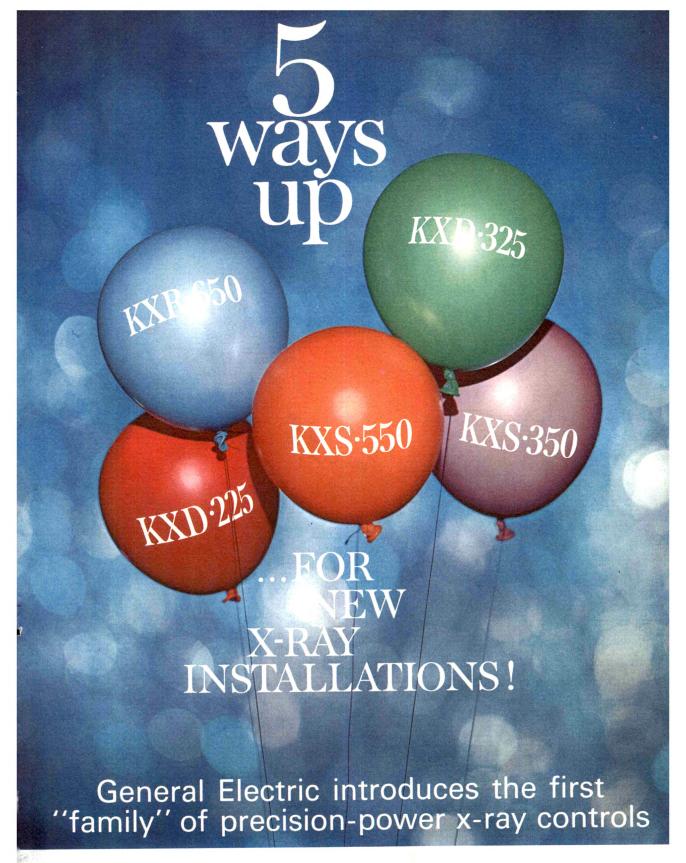
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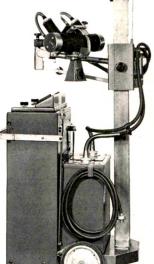


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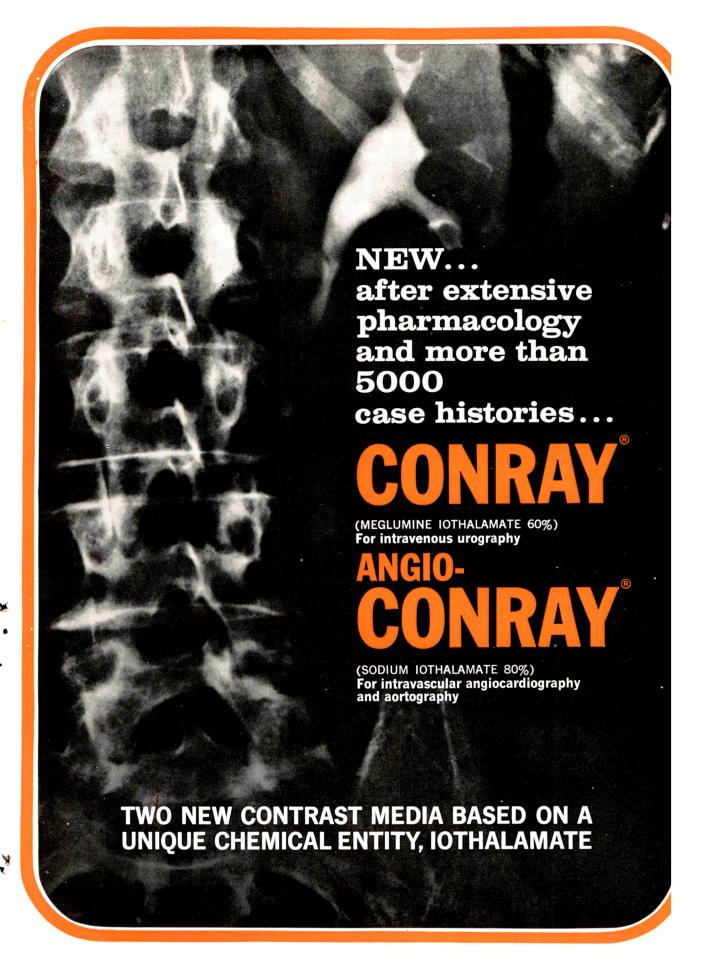
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- 3. Raymond, O.; Nogrady, B., and Vezina, J.: Canad. M.A.J. 82:1077, 1960.
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"Increasing-dose, alternate-injection studies in our laboratory revealed that in dogs there were fewer electrocardiographic changes associated with the intracoronary delivery of \_iothalamate/ than diatrizoate." 1

#### INTRA-AORTIC INJECTIONS IN DOGS

#### Neurologic responses 2

	Number	Immediate		Post-Anesthe	etic Findings	
	of	Neurologic	Neu	rologic:	Ren	al:
	Dogs	Response	Paresis	Paraplegia	Azotemia	Necrosis
Sodium iothalamate 80% (Angio-CONRAY)	20	0	0	0	0	0
Sodium and methylglucamine diatrizoates 90%	30	43%	7%	0	0	0

#### Histological examination of kidneys...

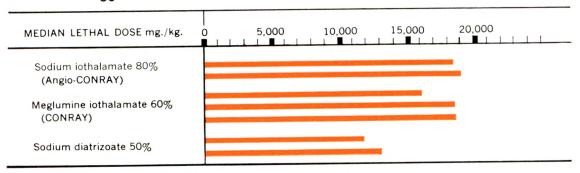
following intra-aortic injection of large doses of iothalamate.

<sup>&</sup>quot;Microscopic sections of both kidneys of all the dogs /10/ were entirely within normal limits. Specifically, there was no evidence of glomerular destruction, tubular damage, casts, or vascular pathology." 4

#### Pharmacological findings: (cont'd)

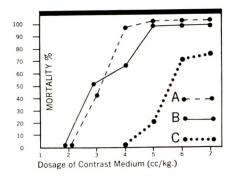
#### **ACUTE TOXICITY**

#### Intravenous LD<sub>50</sub> in mice?



In achieving the acute lethal range in mice and rats, the total volume of undiluted iothalamate solutions administered intravenously was almost equivalent to the estimated total blood volumes of these animals. 9

#### Intravenous injections in dogs 2,15



- A SODIUM ACETRIZOATE 70%
- B SODIUM AND METHYLGLUCAMINE DIATRIZOATES 90%
- C /Angio / CONRAY 80%

"Thus the margin of safety in intravenous injections was far greater with Angio-CONRAY." <sup>2</sup>

#### BLOOD BRAIN BARRIER STUDIES IN DOGS 9,14

Using a modification of previously reported blood brain barrier tests (Broman and Olsson; Whiteleather; De Saussure), intracarotid injections were made in dogs using 25 cc. of meglumine iothalamate 60% and sodium diatrizoate 50% followed by infusion of Trypan blue dye.

	No. of Dogs	None	Barely Perceptible	Faint	Distinct	Intense
25 cc. meglumine iothala- mate 60% (CONRAY)	14	4	3	6	1	0
25 cc. sodium diatrizoate 50%	11	0	0	2	3	6

Even more important than brain staining were the differences in neurological responses when the two media were injected. Dogs receiving sodium diatrizoate (11 dogs) exhibited numerous observable neurological responses such as strong contractions of the neck and thoracic muscles (7 dogs), clonicotonic convulsions and hypersensitivity to sound and touch (9 dogs).

Dogs receiving CONRAY exhibited no convulsions nor hypersensitivity to sound and touch. Four showed slight to mild contractions of the neck and thoracic muscles. The remaining 10 dogs appeared unaffected by the injections.

#### Clinical commentary:

IN OVER 5000 CASES, 1-3, 6, 7, 12-14, 16, 17

there has been general agreement among investigators that patient tolerance with iothalamate has been better than that previously experienced with other available agents.

"...The intravenous injection of  $\overline{\text{CONRAY}}$  observed that "...from this point of view, pleasant reaction." STEINBERG, I. and DOTTER, C. T., et al.1 EVANS, J. A.16

"In view of its several distinct advantages, it is likely that iothalamate will supersede presently available agents for cardiovascular contrast visualization." STRAUBE, K. R. and DOTTER, C. T.17

"At the present time, Angio-CONRAY would appear to be the concentrated angiographic medium of choice." Foster, et al. further state that "experimental studies clearly demonstrated that sodium iothalamate is the least toxic angiographic contrast medium yet tested." FOSTER, J. H., et al.<sup>2, 3</sup>

"If further clinical experience confirms our impression of its relative safety and freedom from side effects, /iothalamate/will, in fact, warrant the term 'drug of choice'-at least until a better preparation is found." Citing the importance of the need for rapid delivery of concentrated contrast media through small bore catheters, Dotter, et al. further

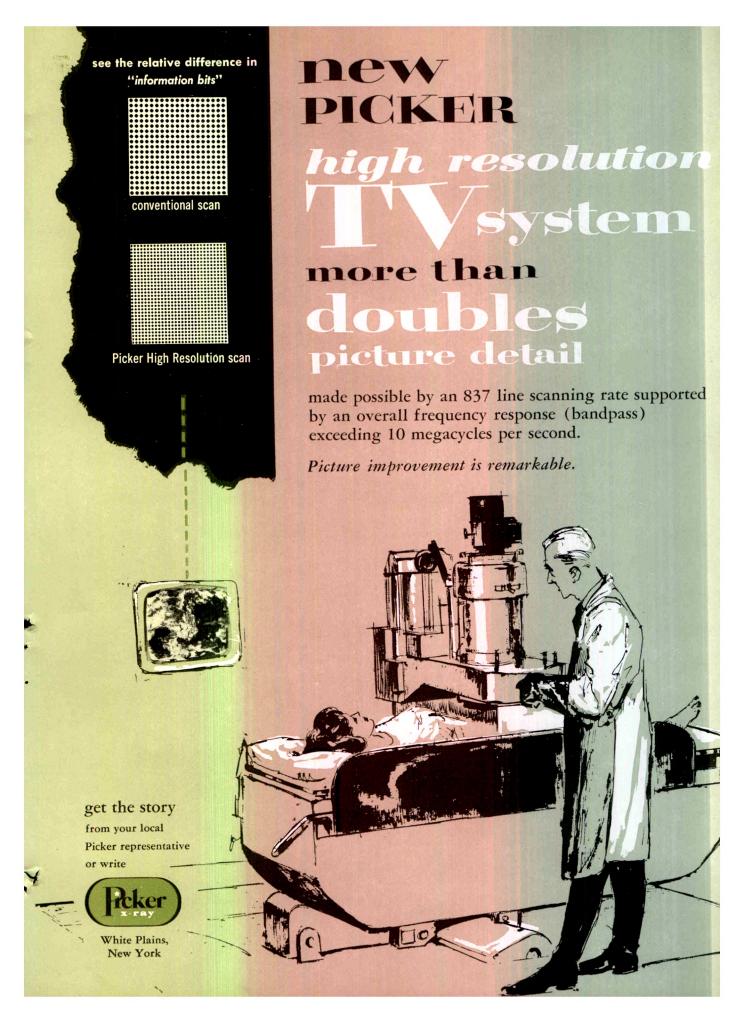
for urography is practically devoid of un- /iothalamate/ is an outstanding medium."

"Clinical experience with a new concentrated contrast agent, Angio-CONRAY, in angiocardiography, nephrotomography, intravenous aortography, and retrograde renal arteriography indicates that the usual reaction was mild and transient, and was well tolerated. Low viscosity and ready solubility of Angio-CONRAY permit ease and speed of injection. These factors, together with good contrast visualization, make Angio-CONRAY a preferable contrast medium for angiographic procedures." KANICK, V. and FINBY, N.7

"Angio-CONRAY is the agent of choice for aortography and angiocardiography. CONRAY is the preferred agent for intravenous urography... It appears that the compound is more rapidly excreted than the other common opaques and maximum density of contrast is evident in five minutes." MARSHALL, T. R. and LING, J. T. 13

#### BIBLIOGRAPHY: CONRAY and ANGIO/CONRAY

1. Dotter, C. T.; Straube, K. R.; Bilbao, M. K., and Hinck, V. C.: New Contrast Medium for Intravascular Use, Northwest Med. 61:41-6 (Jan.) 1962. 2. Foster, J. H.; Sessions, R. T.; Winfrey, E. W.; Killen, D. A., and Collins, H. A.: Clinical and Experimental Evaluation of Angiographic Contrast Media, Scientific Exhibit presented at the 111th Annual Meeting of the American Medical Association, Chicago, Illinois, June, 1962. 3. Foster, J. H.; Winfrey, E. W.; Killen, D. A., and Sessions, R. T.: A New and Superior Angiographic Contrast Medium, Sodium Iothalamate 80%: A Clinical and Experimental Evaluation. To be published. 4. Bernstein, E. F.; Mackey, G. C.; Emmings, F. G., and Amplatz, K.: Experimental Evaluation of Renal and Spinal Cord Tolerance to a New Angiographic Agent, Angio-CONRAY, Surgery 51:663-7 (May) 1962. 5. Bernstein, E. F.; Reller, C. R., and Grage, T. B.: Experimental Studies of Angio-CONRAY: A New Angiographic Agent, Radiology. To be published. 6. Dotter, C. T.; Straube, K. R.; Bilbao, M. K., and Hinck, V. C.: An Initial Report on Iothalamate. A New Contrast Agent for Intravascular Administration, Scientific Exhibit presented at the Annual Meeting of the Radiological Society of North America, Chicago, Illinois, November, 1961. 7. Kanick, V., and Finby, N.: Angio-CONRAY: A New Angiographic Contrast Agent. To be published. 8. Killen, D. A.; Foster, J. H., and Scott, H.W., Jr.: Toxic Reactions Incident to Urokon Aortography as Related to the Volume of Contrast Medium Injected. Addendum.



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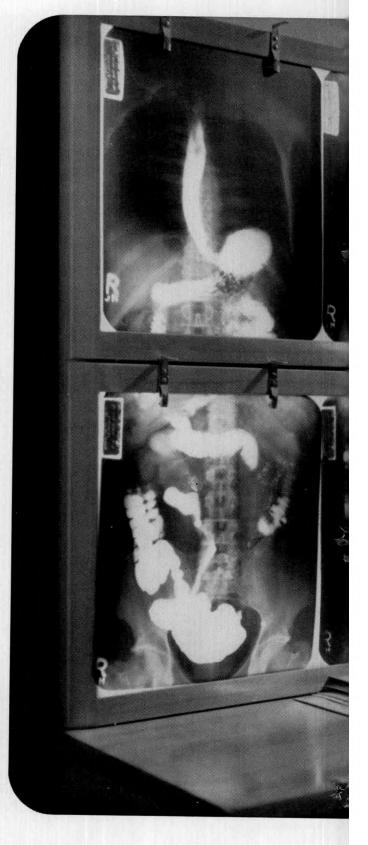
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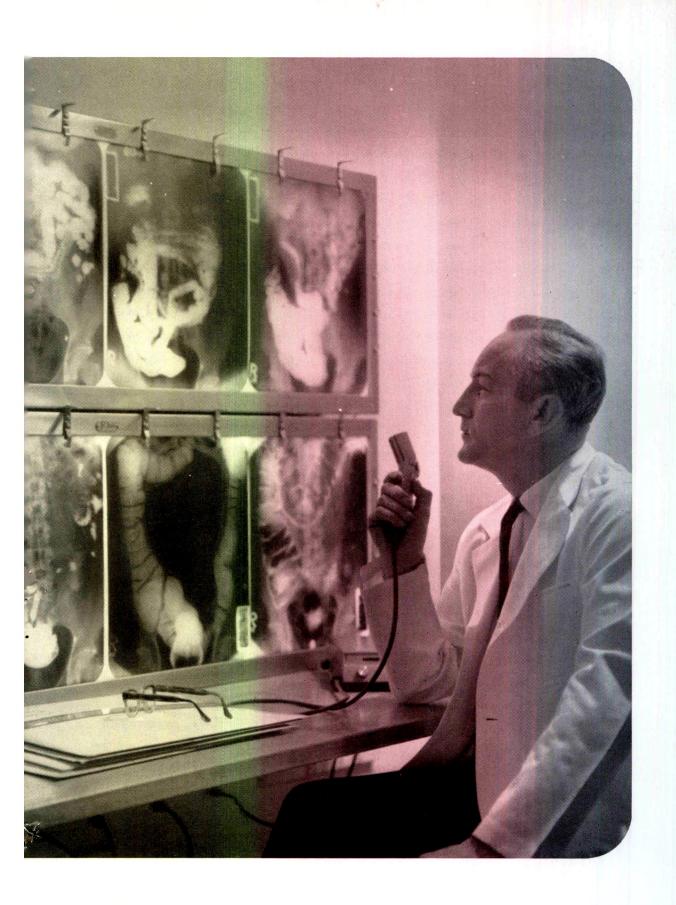
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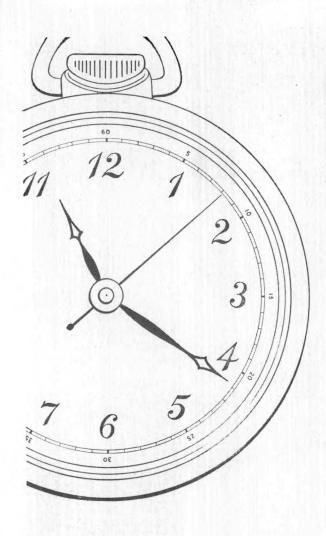
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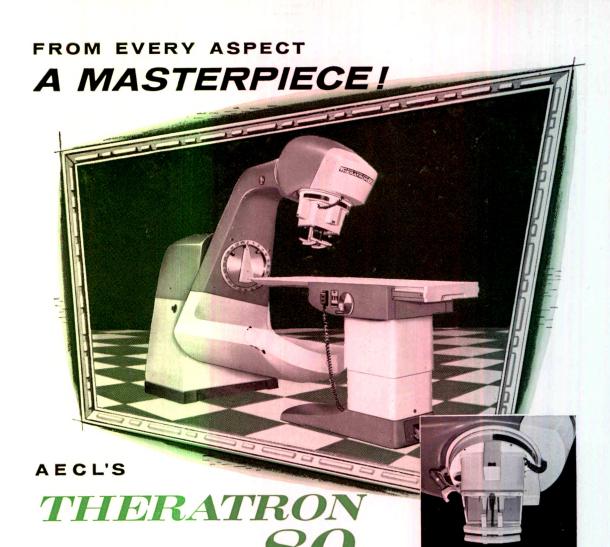
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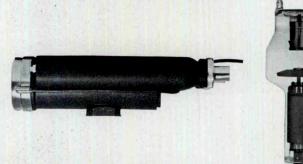
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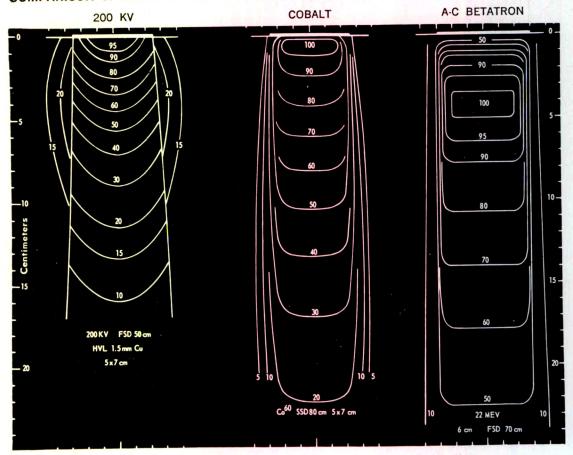
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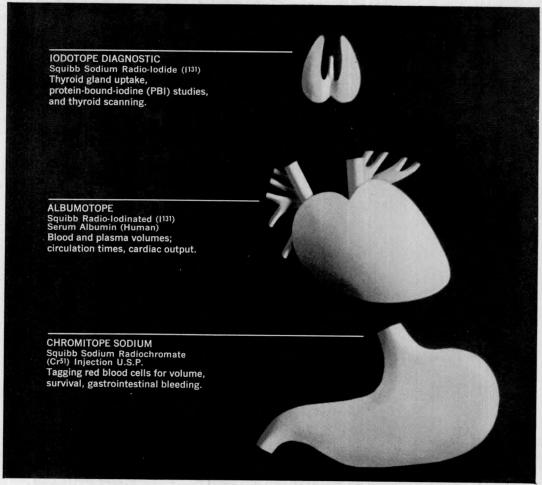
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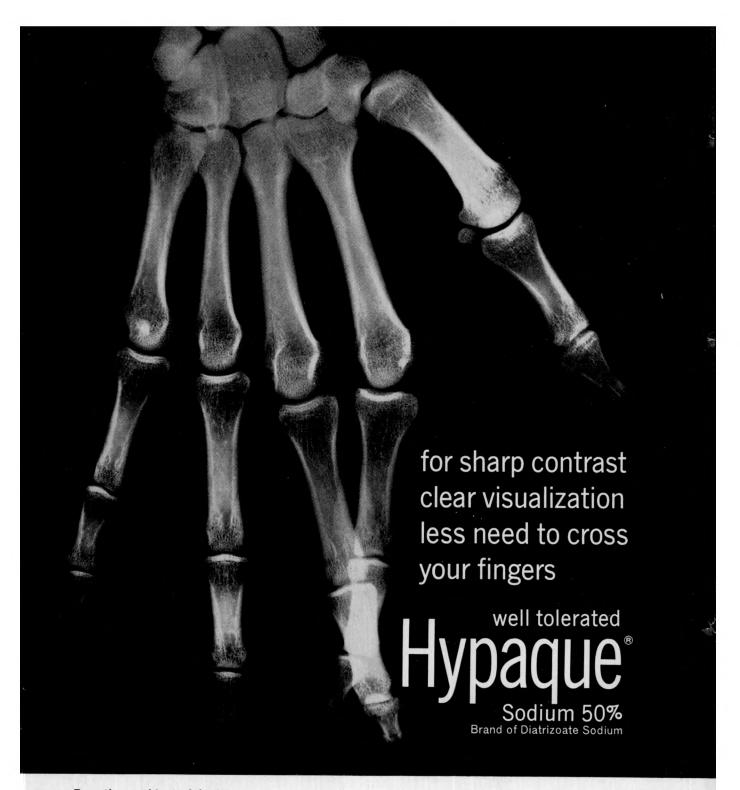
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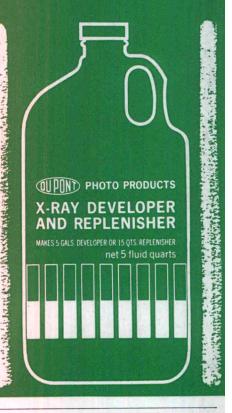




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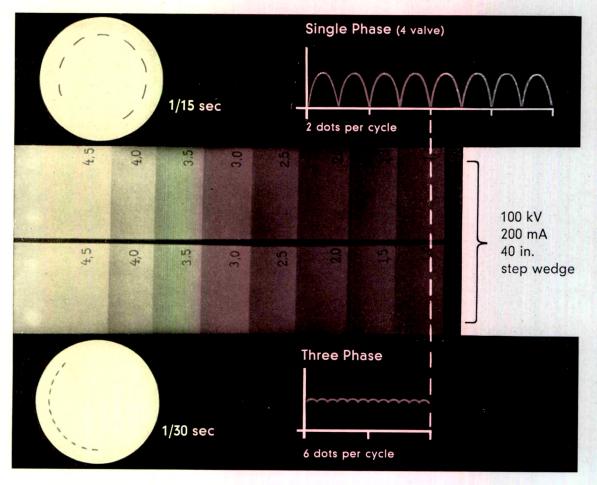
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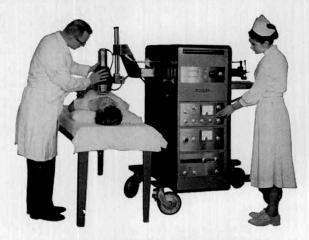
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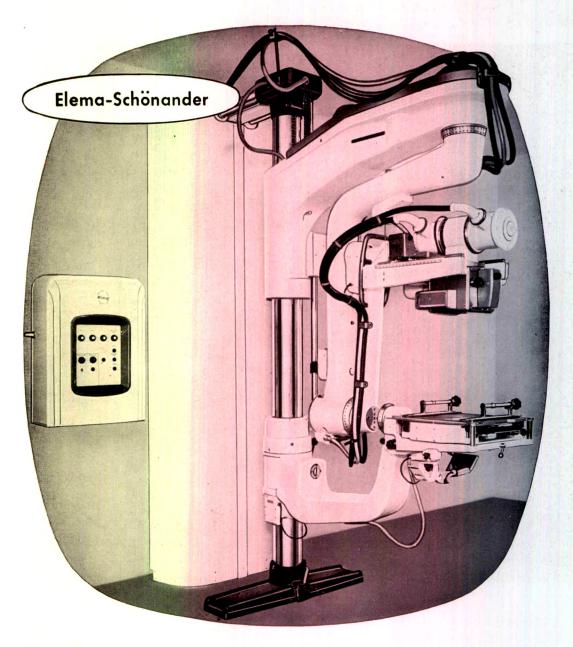
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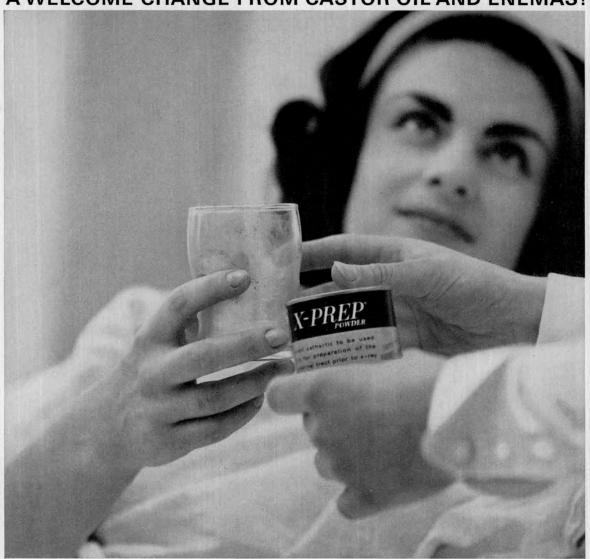
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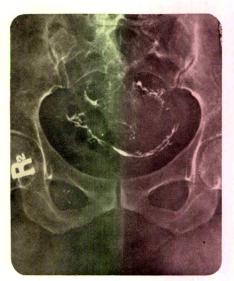
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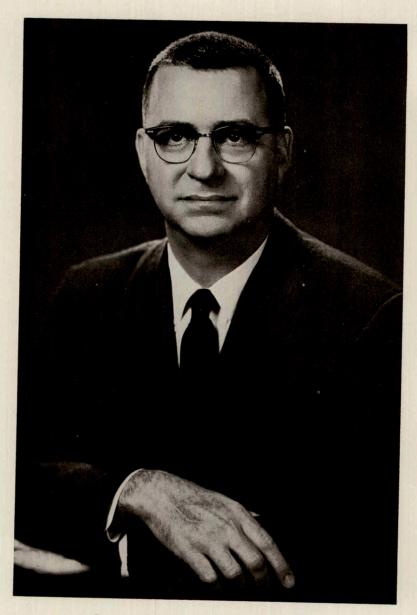
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# RADIUM THERAPY AND NUCLEAR MEDICINE

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No. 4

### INTRODUCTION TO THE CALDWELL LECTURE, 1962

By CLYDE A. STEVENSON, M.D.\* SPOKANE, WASHINGTON

The American Roentgen Ray Society, by hallowed custom, is assembled here tonight to pay respect and tribute to the memory and scientific accomplishments of Dr. Eugene W. Caldwell. Our present day image of this physician, pioneering in the field of diagnostic roentgenology, has not been unduly magnified by the passage of time for he earned the respect and admiration of those contemporary with him and was elected President of our Society in 1908. Only 10 years later he paid the supreme sacrifice, with death due to radiation-induced malignancy. Two years later, in 1920, the American Roentgen Ray Society assembled to hear the first Lecture in his honor just as we are now gathered to hear the forty-second of these annual presentations.

The medical literature records some of Caldwell's contributions, but his real value in securing the foundations of radiology can best be appreciated by reviewing the texts of the many excellent lectures in his honor. For most of you it would be needless repetition to give the details of Caldwell's life and scientific achievements, while for others it need only be

said that the continuing rise in scope and caliber of Radiology is facilitated by the strong foundation he helped build.

The twenty-seventh Caldwell Lecturer, Dr. Merrill C. Sosman, said, "It is well to pause at least once a year to acknowledge our intellectual debts to our predecessors," and, therefore, our President, Dr. Earl E. Barth, has chosen an outstanding scientist, Dr. C. Allen Good, to help make an annual payment on this never-ending debt.

Like Caldwell, Dr. Good was born in Missouri and obtained part of his education in the East. Dr. Good was elected to Phi Beta Kappa at Williams College and graduated cum laude. The same level was maintained at Washington University Medical School with election to Alpha Omega Alpha and again graduating cum laude in 1933. At Williams he earned prizes for outstanding work in chemistry and in physics, and when halfway through Medical School was co-author of a scientific paper. This academic success gave clue to the future, for the twenty-eighth Caldwell Lecturer, Dr. B. R. Kirklin, in his talk on "Graduation Education in Roentgenol-

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ogy," said that his choice of a student for training in Radiology depended first on grades obtained in college and medical school and then on interest, drive and motivation.

Dr. Laurence L. Robbins, a recent Hickey Lecturer, in discussing problems of resident training in Radiology said, "Hopefully, it will be recognized that an intelligent and industrious person fulfilling the requirements in the field of Radiology is a very capable person and fully able to assume many responsible positions."

It is inspiring to keep these criteria in mind as we trace the development of our Caldwell Lecturer of this evening. I first met Dr. Good when we started our radiological training at the Mayo Clinic under the guidance of Drs. Kirklin, Camp, Weber and Sutherland. Dr. Good's scholarly ability and compatible personality were soon evident and, because of his association with Drs. Kirklin and Weber, it was only natural that the roentgen diagnosis of chest and gastrointestinal disease became his main interest. To date, he has contributed 83 important papers to the medical literature and has presented several prize winning exhibits at the American Roentgen Ray Society and the American Medical Association annual meetings. A significant characteristic of all his work is an unflinching determination to meet any task, small or great, odious or pleasurable, to the utmost of his ability. Recently, one of his associates told me that he was repeatedly amazed at the effort Dr. Good put into a small bowel examination, his refusal to take any short cuts, and his success in obtaining the highest possible diagnostic yield. All of Dr. Good's diagnostic work bears this same stamp. Special recognition of his scientific status has come often as evidenced by faculty participation in postgraduate courses and invitations to give the Carman Lecture of the St. Louis Medical Society, the Hickey Lecture of the Detroit

Roentgen Ray and Radium Society, and the Carman Lecture of the Minnesota Radiological Society.

Because of the nature of the specialty of Radiology, administration often takes considerable time and effort and here Dr. Good fulfills Dr. Robbins' wish in being able to capably assume many responsibilities. He has been President of the Minnesota Radiological Society, served 9 years (3 as Chairman) on the Scientific Exhibit Committee of the American Roentgen Ray Society, was a member of the Executive Council and has been Secretary of the Society since 1957. The American College of Radiology and the Minnesota State Medical Association have also claimed his services. In 1958, Dr. Good became Head of the Section on Diagnostic Roentgenology in the Mayo Clinic and is now Professor of Radiology in the Mayo Foundation Division of the University of Minnesota Graduate School. This recognition of his scientific and administrative ability was increased by appointment to the Board of Governors of the Mayo Clinic, a position he has held for the past 6 years.

In a most successful manner, Dr. Good heads 11 radiologists, 34 fellows in training, and a technical staff of 158. Dr. Good continually pays his intellectual debt to his predecessors by making a devoted hobby of training his residents and serving on the American Board of Radiology.

It has been said that the high status of this Lectureship is based on the authority of the oldest radiological organization in the United States and the eminence of the previous Caldwell Lecturers. It is easy to see that Dr. Barth has added luster to this list.

Ladies and Gentlemen, it is with extreme pride and pleasure that I introduce to you the Caldwell Lecturer for 1962, Dr. C. Allen Good.

### TUMORS OF THE SMALL INTESTINE\*

CALDWELL LECTURE, 1962

By C. ALLEN GOOD, M.D.

Section of Roentgenology, Mayo Clinic and Mayo Foundation

ROCHESTER, MINNESOTA

Tumors of the small intestine are rare. When one considers the total length and surface area of the duodenum, jejunum and ileum and compares them with the total length and surface area of the esophagus, stomach and colon, one cannot help but be impressed by the frequent occurrence of tumors in these latter segments and by the rare occurrence in the former.

#### INCIDENCE

Ewing<sup>2</sup> estimated that only 3 per cent of neoplasms of the gastrointestinal tract occur in the small intestine. Raiford<sup>3</sup> placed the frequency at 6.5 per cent.

In the 20 year period January 1, 1938, through December 31, 1957, 659 tumors of the small intestine were encountered at the Mayo Clinic. Three hundred and four of these were found at necropsy and 355 at operation. During the same period, approximately 21,000 patients with benign and malignant tumors of the stomach and colon were operated upon. Thus in the surgical material at the Mayo Clinic for a period of 20 years, tumors of the small intestine constitute 1.7 per cent of all gastrointestinal tumors.

About half of the 659 tumors were benign and half were malignant (Table 1). Fortytwo per cent produced significant clinical symptoms and signs, while the remainder were discovered incidentally at operation or necropsy. Carcinoid tumor was the most common, but adenocarcinoma was more frequently the cause of symptoms. In addition to these two tumors, malignant lymphoma, benign and malignant tumors arising from smooth muscle, adenomatous polyp, lipoma and hemangioma occurred with significant frequency and will be dis-

cussed in some detail later. Less common tumors included lymphangioma, fibroma, adenoma of Brunner's glands, neurogenic tumor and malignant angiogenic tumor.

#### CLINICAL FEATURES

Predominant clinical symptoms and signs were those associated with partial or complete intestinal obstruction, loss of weight, evidence of loss of blood, and a palpable abdominal mass (Table II). Less common symptoms were diarrhea, weakness, fever and pallor.

Seventy-two per cent of patients with tumors that produced symptoms complained of pain or signs of partial intestinal obstruction. Specific complaints were distention, rapid filling on eating, vomiting, cramping pain, borborygmus and visible

#### TABLE I

NEOPLASMS OF THE SMALL INTESTINE ENCOUNTERED AT THE MAYO CLINIC, JANUARY 1, 1938, THROUGH DECEMBER 31, 1957, BY TYPE AND SOURCE OF MATERIAL

Histologic Type	Cases			
of Neoplasm	Necropsy	Surgical	Total	
Malignant				
Carcinoid tumor	85	67	152	
Adenocarcinoma	8	77	85	
Malignant lymphoma	8	47	55	
Leiomyosarcoma	I	34	35	
Other	2	2	4	
Benign		1 5 5		
Leiomyoma	63	56	119	
Adenomatous polyp	40	27	67	
Lipoma	34	19	53	
Hemangioma	33	10	43	
Other	30	16	46	
Total	304	355	659	

<sup>\*</sup> Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 2-5, 1962.

TABLE II
CLINICAL FEATURES

	Cases	Pain or Obstruction or Both	Loss of Weight	Anemia or Bleeding or Both	Palpable Mass
Carcinoid	49	28	29		
Adenocarcinoma	77	69	66	54	21
Lymphoma	54	51	36	19	30
Leiomyosarcoma	34	17	22	28	19
Leiomyoma Adenoma	29	17	11	23	7
Lipoma	11	7	_	7	2
	15	13	3	6	4
Hemangioma	10			10	-
Total cases	279	202	167	147	108
Per cent	100	72	60	52	39

peristalsis. Only in patients with hemangiomas was this symptom complex lacking.

Sixty per cent of patients had experienced some loss of weight. This was encountered more often among patients with symptomatic malignant tumors (71 per cent) than among those with symptomatic benign tumors (22 per cent).

Except in cases of carcinoid tumor, evidence of loss of blood was common. Fifty-two per cent of all patients with a symptomatic tumor had experienced hematemesis, melena, plum-colored blood in the stool or secondary anemia with a hemoglobin value of less than 12 gm. per 100 ml. of blood. In this group, 64 per cent of patients with adenomatous polyp, 70 per cent of those with adenocarcinoma, 81 per cent of those with benign or malignant smooth-muscle tumor and 100 per cent of those with hemangioma gave evidence of loss of blood from the gastrointestinal tract.

A mass was palpable in the abdomen of 39 per cent of patients with a tumor of the small intestine. This was a more common finding in patients with a malignant tumor (44 per cent) than in patients with a benign tumor (20 per cent).

#### ROENTGENOLOGIC MANIFESTATIONS

Several roentgenologic methods are available by which signs of a tumor in the small

intestine can be elicited. If significant obstruction has occurred, a roentgenogram of the abdomen without the use of contrast material may show evidence of it. The characteristic gaseous distention, "ladder effect" and presence of multiple fluid levels may be sufficient warning that other roentgenologic procedures are inadvisable. These signs are not indicative of tumor alone, for other causes of obstruction, such as adhesive bands, infarction and inflammatory stricture, may produce the same patterns on the roentgenogram. Usually, however, further roentgenologic studies are not indicated unless the obstruction can be relieved readily.

Contrast material such as barium in suspension or a water-soluble iodinated compound can be employed in a number of ways. It can be given by mouth, introduced into the duodenum through a tube as a "small-bowel enema," or injected into a Miller-Abbott tube that has been allowed to progress as far down the intestine as possible. In some instances, the introduction of contrast material through the rectum in retrograde fashion will opacify the terminal portions of the ileum and allow proper delineation of a tumor arising in this segment of the bowel.

Regardless of its method of introduction, contrast material produces certain charac-

teristic patterns which may be indicative of the presence of a tumor.

The first of these is complete obstruction (Fig. 1). While this pattern is not alone a sign of tumor since it can be produced by anything that prevents the advance of intestinal contents, it does permit an estimation of the location of the lesion and, on a percentage basis, a neoplasm becomes one of the leading possibilities in the differential diagnosis.

A second pattern is that produced by intussusception (Fig. 2, a and b). In this condition, which comes about because the intestine attempts to pass a tumor along its lumen in order to eliminate it, a loop of bowel, the intussusceptum, is enfolded into the receiving loop, the intussuscipiens, in such a manner as to produce a characteristic picture. First the contrast material passes through the narrow channel of the



Fig. 1. Complete obstruction in proximal portion of jejunum caused by annular adenocarcinoma. Site of obstruction is easily recognized, although nature of lesion causing it cannot be determined with certainty.

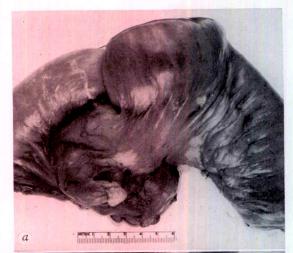




Fig. 2. Intussusception caused by adenocarcinoma of jejunum. (a) Excised segment with mesentery. (b) Roentgenogram showing typical appearance. Narrow channel of intussusceptum passes through "concentric rings" of intussuscipiens. Exact nature of lesion causing intussusception cannot be determined.

intussusceptum and then refills the lumen of the intussuscipiens by reflux, giving the "concentric-ring" or "stacked-coin" effect. Intussusception can be produced by lesions other than tumor, such as by an invaginated Meckel diverticulum, but in the adult patient it is commonly the result of a tumor, either benign or malignant. This roentgenologic pattern permits an estimation of the location of the lesion although it does not always permit a precise histologic diagnosis.

Local filling defects in the opacified in-

testinal lumen not only show the site of a tumor, but also may indicate its histologic nature. Three types may be recognized: (1) intraluminal, (2) mucosal or ulcerating and (3) intramural. Each produces a characteristic pattern which usually can be recognized roentgenographically.

An intraluminal defect is produced by a tumor that lies almost entirely within the lumen of the bowel. The neoplasm is attached to the wall of the intestine by means of a pedicle which allows the tumor to move up and down within the lumen for a distance equal to twice the length of the pedicle. No matter from what angle the filling defect is seen, be it en face or in lateral projection, the roentgenologic appearance is the same (Fig.3, a and b). It may be a round, oval or lobulated defect in the column of opaque material, frequently movable over a short distance. Sometimes the pedicle may be identified, at other times not.

The tumor that exhibits these characteristics most commonly is the adenomatous polyp. However, many of the con-

nective-tissue tumors, such as leiomyoma, fibroma, lipoma and ganglioneuroma, can become pedunculated and lie entirely within the lumen of the intestine.

Tumors that arise from the mucosa and that therefore destroy its normal appearance produce the "mucosal" or "ulcerating" defect (Fig. 4, a and b). These masses may completely encircle the lumen or may show ulcerations of varying depth. In all instances, the normal pattern of mucosal folds is destroyed and the demarcation between normal and abnormal is sudden and abrupt. The mass may predominate and encroach upon intestinal lumen, or the wall of the bowel may be partially destroyed, making the lumen larger. Tumors commonly producing this type of defect are adenocarcinoma and malignant lymphoma.

The third, or intramural, defect is produced by any tumor that arises within the wall of the intestine but does not involve the mucosal surface primarily (Fig. 5, a, b, c and d). The mass may grow toward the lumen, pushing the mucosa ahead of it. Mucosal folds may be flattened but are not

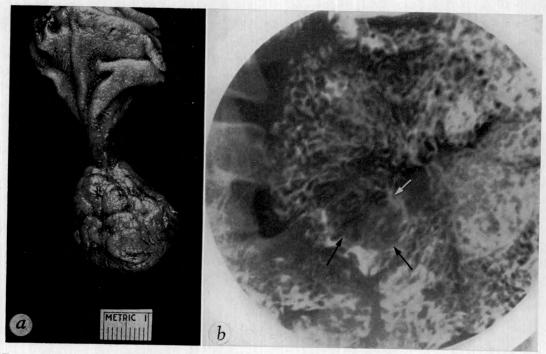


Fig. 3. Adenomatous polyp of jejunum. (a) Photograph of polyp and small portion of wall of jejunum after removal. (b) Spot roentgenogram showing intraluminal defect caused by polyp (arrows).

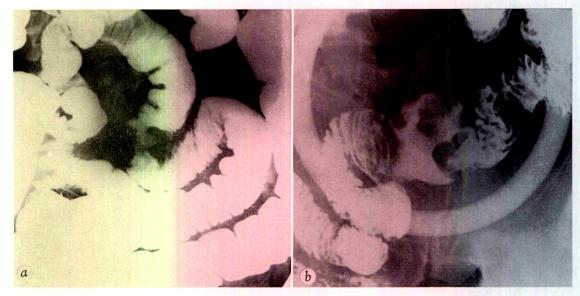


Fig. 4. (a) Annular, ulcerating adenocarcinoma of ileum producing mucosal type of filling defect on spot roentgenogram. Lumen is encroached upon by tumor. In this case, ileum was filled at time of barium enema. (b) Hodgkin's variety of malignant lymphoma producing mucosal type of filling defect on spot roentgenogram. In this case, lumen is widened because of extensive ulceration of tumor.

destroyed as with ulcerating or mucosal tumor. The lumen may be encroached upon, but the base of the mass as it indents the lumen is always at least as broad as the part that projects within. This feature is seen best when the lesion is projected tangentially. If seen *en face*, the defect can be similar to that produced by an intraluminal tumor

The lesions commonly causing this type of filling defect are those of smooth-muscle origin, either benign or malignant, and lipoma, hemangioma and carcinoid.

Sometimes an intramural tumor may be associated with ulceration of the mucosa (Fig. 6, a and b). This ulcer is customarily small, but the crater may extend into the intramural mass of the lesion. Ordinarily, it is not difficult to distinguish this type of ulcer from the massive ulceration associated with the ulcerating type of neoplasm that arises from the mucosa.

At other times, an intramural tumor will grow in the direction of the serosa and will produce a mass that is predominantly extrinsic (Fig. 7). There may be little or no encroachment on the lumen. In such cases, neighboring loops of bowel are pushed away

and the only defect occurs as a "blank space" between filled loops. This type of pattern is most likely to be produced by a smooth-muscle tumor or a carcinoid.

A smooth-muscle tumor may combine features of the intramural and extrinsic patterns, encroaching on the lumen and flattening the mucosal folds and also producing a relatively large extrinsic mass displacing neighboring loops. Such is known as a dumbbell tumor.

Finally, a carcinoid tumor, which usually is tiny and often unrecognized roentgenologically at the primary site, may extend to mesenteric lymph nodes and mat together several loops of intestine in such a manner that individual loops cannot be separated by manipulation (Fig. 8). In such instances, there may develop an abrupt kink in the lumen of the bowel which remains constant during all stages of the examination.

#### CARCINOID TUMOR

Carcinoid tumors arise from the argentaffin cells situated in the base of the crypts of Lieberkühn. The primary tumor is usually small, submucosal in location and may be multiple. Metastasis to regional

lymph nodes and to the liver occurs in 25 per cent of cases and these secondary deposits are frequently more bulky than the original tumor.

In our experience, carcinoid was the most common tumor of the small intestine, making up 23 per cent of the series of 659 neoplasms (Table 1).

Less then one third of the 152 carcinoid

tumors in the Mayo Clinic series produced clinical symptoms and signs (Table II). These manifestations could be divided into those with local effect and those with systemic effect. The local effect of partial or complete intestinal obstruction, observed in 28 patients (57 per cent) with symptom-producing carcinoids, was almost always caused by the mass of metastatically in-

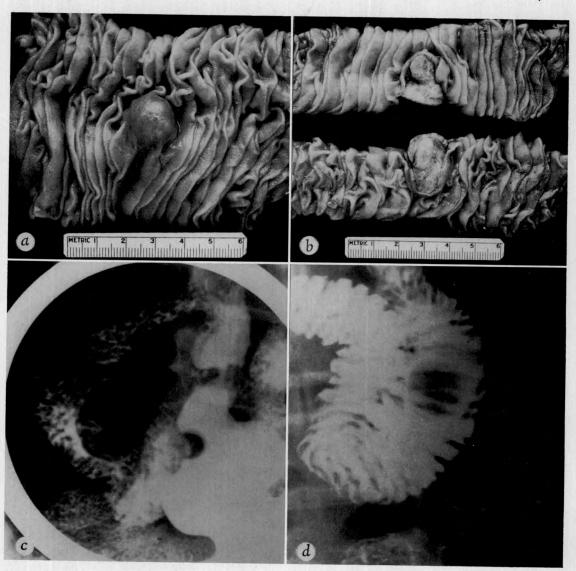


Fig. 5. Small intramural leiomyoma of jejunum. (a) Photograph of mucosal surface of excised segment of jejunum. Over tumor, mucosa is flattened, while adjacent folds are not disturbed. (b) Specimen shown in a has been sectioned down the middle and tumor turned to show its submucosal position. (c) Spot roentgenogram showing characteristic intramural type of filling defect in second portion of duodenum as it appears when viewed tangentially. (d) Spot roentgenogram of similar intramural tumor in jejunum viewed en face.

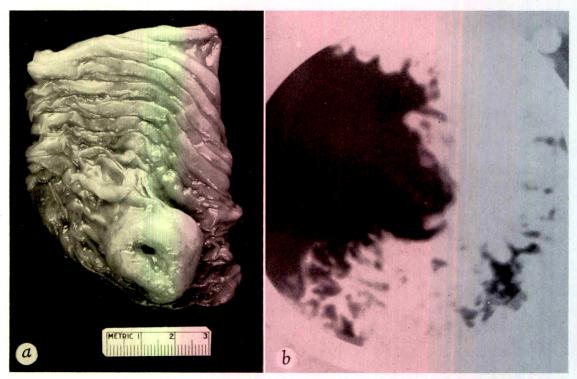


Fig. 6. (a) Intramural leiomyoma with small ulcer of overlying mucosa. Crater extends into mass of tumor. (b) Spot roentgenogram showing typical intramural filling defect with niche of ulcer extending into it.

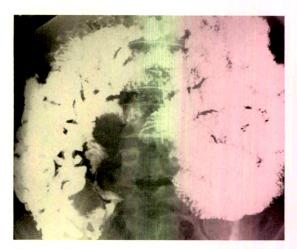
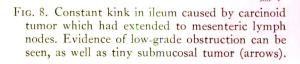


Fig. 7. "Blank space" between barium-filled loops of small intestine caused by tumor of smooth muscle which has originated in a segment of ileum just to right of shadow of fifth lumbar vertebra.





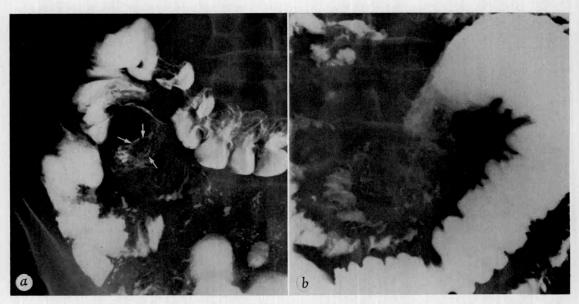


Fig. 9. (a) Small submucosal carcinoid 1.5 cm. in diameter (arrows) in ileum about 5.0 cm. from ileocecal valve. Large extrinsic mass of mesenteric lymph nodes distorts appearance of terminal portion of ileum (see text). (b) Partial obstruction caused by carcinoid tumor. Several small submucosal nodules can be seen, as well as large extrinsic mass which displaces neighboring uninvolved loops of ileum (see text).

volved mesenteric lymph nodes and the resulting agglutination and kinking of the neighboring loops of intestine. A mass was

TABLE III

NEOPLASMS OF THE SMALL INTESTINE ENCOUNTERED AT THE MAYO CLINIC, JANUARY I, 1938, THROUGH DECEMBER 31, 1957, BY TYPE AND SITE OF OCCURRENCE

Tr. 1 . T.	Site of Occurrence			
Histologic Type of Neoplasm	Duode- num	Jejunum	Ileum	
Malignant				
Carcinoid tumor	4	10	138	
Adenocarcinoma	41	37	7	
Malignant lymphoma	I	26	28	
Leiomyosarcoma	9	12	14	
Other	1	2	I	
Benign				
Leiomyoma	25	57	37	
Adenomatous polyp	14	24	29	
Lipoma	17	9	27	
Hemangioma	I	24	18	
Other	11	14	21	
Total	124	215	320	

palpable in the abdomen of 21 of these patients.

Loss of weight was noted by 29 patients with a symptomatic carcinoid tumor, or in 19 per cent of the 152 patients found to have such a tumor.

The systemic effect produced by carcinoid tumors is caused by the elaboration of the substance serotonin, or 5-hydroxytryptamine (5-HT). Patients with functioning carcinoid tumors complain of attacks of flushing of the skin of the face and neck, often precipitated by ingestion of food or alcohol or by pressure on the primary or secondary deposits of tumor. This is sometimes accompanied by a fall in systolic and diastolic blood pressure and an increase in pulse rate. Telangiectasis may develop in the skin of the face and legs. Serotonin may also produce respiratory distress similar to asthma, digestive disturbances such as diarrhea, and symptoms attributable to peptic ulcer. Certain right-sided cardiac lesions also have been thought to be associated with the increased production of serotonin. These patients may experience dyspnea on exertion and fatigability.

These systemic effects, the "carcinoid syndrome," were found rarely in this group of patients, and almost always in cases in which there were large metastatic implants in mesenteric lymph nodes or liver.

Carcinoid tumor occurs most often in the distal segments of the ileum. More than 90 per cent of the 152 lesions in the Mayo Clinic series were located in this portion of

the bowel (Table III).

The attempt at roentgenologic diagnosis of carcinoid tumor has been almost uniformly unsuccessful at the Mayo Clinic. In one case, the agglutination of neighboring loops of ileum, resulting in the production of a sharp kink and low-grade obstruction, was described, although the precise histologic nature of the lesion was not recognized (Fig. 8). In another case, an extraluminal mass was found, which distorted the opacified lumen of the ileum near the ileocecal valve (Fig. 9a). Although in this instance the clinical findings suggested the presence of a carcinoid, there was nothing in the roentgenologic appearance that would lead to such a specific diagnosis. In one other case, partial intestinal obstruction was recognized in the ileum (Fig. 9b). Several small, submucosal nodules were noted in the involved loop, together with a larger extrinsic mass. These manifestations should have suggested carcinoid tumor, although for some reason the examiner did not mention this diagnosis in his report.

The frequent lack of roentgenologic recognition is probably attributable to the usually small size of the submucosal tumor (less than I cm. in diameter) and the difficulty experienced in delineating it, and to the fact that almost always the roentgenologic manifestations are caused by extensions of the neoplasm into the mesenteric

lymph nodes.

#### ADENOCARCINOMA

Whereas carcinoid was the most common tumor in the entire series of 659 cases, adenocarcinoma was the most frequent cause of clinical manifestations. Seventy-seven of 85 such lesions produced symp-

toms that warranted surgical exploration. Sixty-nine of these patients exhibited signs of partial or complete intestinal obstruction, 66 showed evidence of loss of weight, and 54 were anemic, while 17 had experienced demonstrable bleeding from the gastrointestinal tract. In 25, a mass was palpable in the abdomen (Table II).

Ninety-two per cent of adenocarcinomas were found in the duodenum or jejunum, which is in direct contrast to the location of

the carcinoid tumors (Table III).

Roentgenologic discovery and identification of adenocarcinoma was successful much more frequently than was true of carcinoid tumor. The roentgenologic manifestations were those associated with similar lesions found in the colon or esophagus: (1) a short, sharply demarcated filling defect, frequently annular, (2) loss of normal pattern of mucosa, (3) an eccentric and irregular channel through the lesion and (4) frequent evidence of partial obstruction as shown by dilatation of the bowel proximal to the neoplasm (Fig. 10, a, b, c and d).

Adenocarcinomas that were overlooked were likely to be located more distally, and were often situated within the bony confines of the pelvis, a fact that rendered them relatively inaccessible to palpation and allowed them to be obscured by opacified normal intestine. In some cases, intussusception or complete obstruction was recognized by the examiner, but the exact histologic nature was not identified because of the fact that these secondary manifestations might also be produced by other lesions.

In certain instances, surgical exploration was undertaken because of the presence of a palpable mass or because of manifest intestinal obstruction before a roentgenologic examination of that portion of the bowel had been carried out. In those cases in which a complete roentgenologic examination of the small intestine was permitted and a lesion was discovered, a proper diagnosis could almost always be made unless complete obstruction or intussusception was present.

#### MALIGNANT LYMPHOMA

Fifty-five of the 659 tumors in this series were malignant lymphomas. All but one caused clinical symptoms and signs. In 51 cases, the patient had experienced pain or signs of partial intestinal obstruction; in 36, there was evidence of loss of weight; in 19, there was anemia or other signs of bleeding from the gastrointestinal tract; and in 30, a mass was palpable in the abdomen (Table II). Forty-seven of the

tumors were found at the time of surgical exploration and 8 at necropsy. About half of the lymphomas were situated in the jejunum and half in the ileum. Only I was found in the duodenum. Histologically, these lesions were divided among the lymphocytic, reticulum cell, Hodgkin's and giant follicular types.

Roentgenologically, 3 varieties were recognized: the mucosal type which exhibited many of the manifestations of

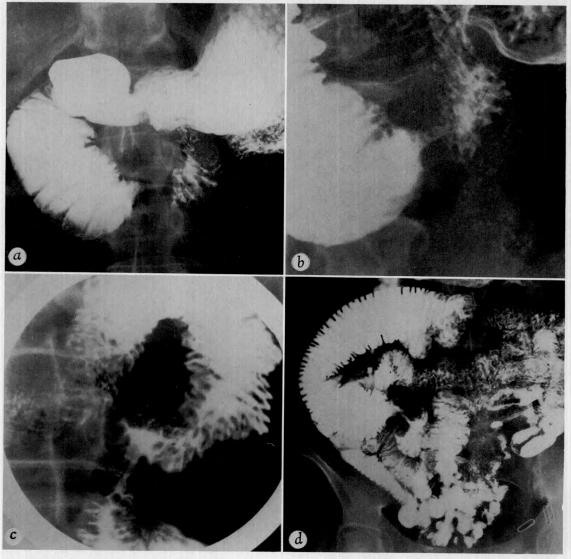
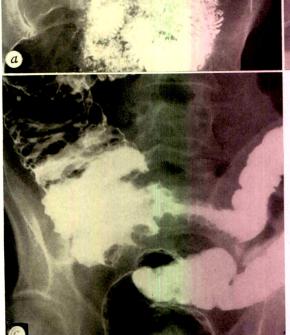


Fig. 10. Three cases of adenocarcinoma demonstrating characteristic roentgenographic appearance. (a and b) Short, sharply demarcated, annular defect in third portion of duodenum. There is partial obstruction. (c) Similar lesion in jejunum demonstrating loss of normal pattern of mucous membrane throughout extent of tumor. (d) Similar lesion showing irregular channel through annular lesion and evidence of partial obstruction.



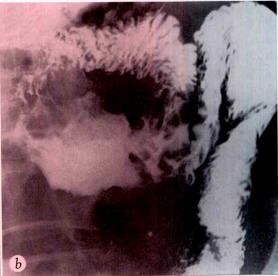


Fig. 11. Three cases of malignant lymphoma demonstrating: (a) sharply demarcated mucosal type of filling defect showing signs of extensive ulceration; this is similar in appearance to that produced by adenocarcinoma; residual barium in descending colon from prior examination partially obscures lesion, which can be seen at level of crest of left ilium; (b) aneurysmal variety in which lumen is increased in diameter by extensive ulceration of tumor; and (c) diffuse involvement of right colon and terminal ileum by numerous small submucosal nodules.

adenocarcinoma, the "aneurysmal" type which was unlike any other tumor, and the diffuse type.

Most frequently, lymphoma caused mucosal, ulcerating changes similar to those of adenocarcinoma (Fig. 11a): a short sharply demarcated defect with loss of normal mucosal pattern and an eccentric, ragged channel through the mass. In such cases, the roentgenologic impression was usually that of carcinoma unless the clinical findings were suggestive of malignant lymphoma.

In the "aneurysmal" variety, the ulcerative features predominated to such an ex-

tent that the lumen of the bowel was increased in diameter rather than decreased (Fig. 11b). Normal mucosal pattern was replaced by ulceration and the defect was abruptly demarcated. Often the site of involvement was longer that that of carcinoma. In some cases, there were multiple sites of involvement and this feature was strongly suggestive of the correct diagnosis.

Diffuse involvement of a long segment of the small intestine alone was not seen in this group of cases. Wolf and Marshak<sup>4</sup> have described numerous small submucosal nodules, closely spaced and occurring in the colon and terminal ileum, which produce a

cobblestone appearance similar to that of the edema of mucosa and submucosa often seen in acute enteritis before granulomatous changes have taken place. At the Mayo Clinic we have observed this type of involvement in the colon and terminal portion of the ileum in I case (Fig. IIc).

#### TUMORS ARISING FROM SMOOTH MUSCLE

Thirty-five of the 659 tumors in this series were leiomyosarcomas and 119 were leiomyomas. Taken together, they were slightly more common than carcinoid tumor. Because their roentgenologic manifestations are frequently similar and because the pathologist often has difficulty distinguishing the malignant from the benign variety, they will be discussed together.

Twenty-two per cent of these tumors were found in the duodenum, 45 per cent in the jejunum and 33 per cent in the ileum (Table III).

Ninety were encountered at the time of surgical exploration and 64 at necropsy, yet

only 63 produced clinical signs and symptoms; 34 of these were malignant and 29 benign (Table II). In 34 cases, there was some evidence of intestinal obstruction, in 33 the patient had experienced loss of weight, in 26 a mass was palpable, and in 51, or 81 per cent, there were signs of gastrointestinal bleeding. This latter feature, exceeded in percentage only in cases of hemangioma, is worthy of special comment. All of these patients had noticed evidence of gross loss of blood. Usually this was in the form of melena or plum-colored blood in the stool. Characteristically, the bleeding was massive, sometimes almost exsanguinating. Once it ceased, it might not recur for weeks, months or years. This type of massive bleeding was in marked contrast to the usual constant oozing of blood experienced by patients with adenocarcinoma.

Roentgenologically, these tumors could be classified as intraluminal, submucosal, subserosal and dumbbell. The intraluminal lesions were pedunculated and could not be distinguished from other lesions exhibiting

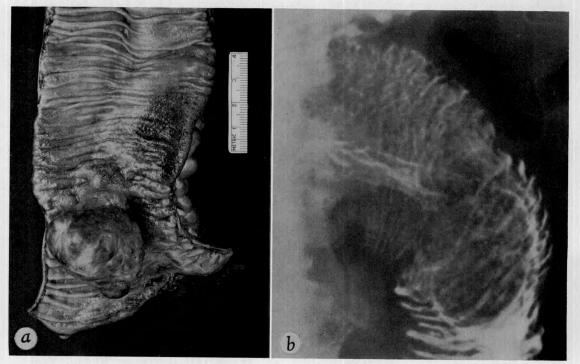


Fig. 12. (a) Intraluminal leiomyoma. This variety produces an intraluminal filling defect similar to that shown in Figure 3b. (b) Intussuscepting leiomyoma in upper part of jejunum.

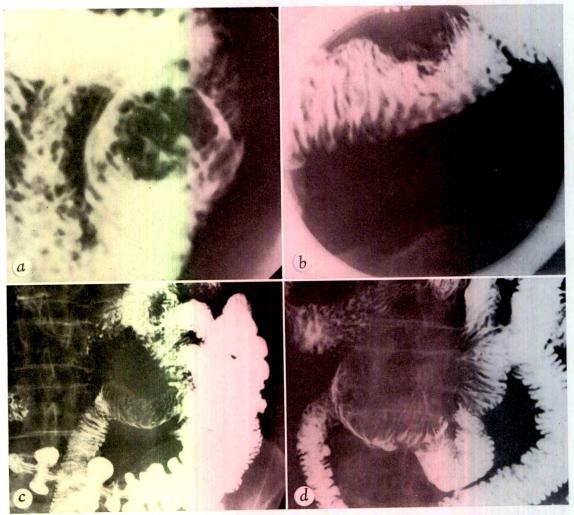


Fig. 13. Three cases of tumors of smooth muscle demonstrating submucosal type of filling defect. (a) Small leiomyoma seen en face. (b) Small leiomyoma seen in profile. (c and d) Larger leiomyosarcoma.

similar gross characteristics (Fig. 12a). This pathologic form occurred seldom but was sometimes the cause of intussusception (Fig. 12b).

Subserosal tumors were most common and were asymptomatic for the most part. When small, they were unrecognized roent-genologically and were discovered as incidental findings at necropsy or surgical exploration carried out for the treatment of some other condition. If large, these tumors could be recognized as a mass, attached to the intestine and indenting its lumen, but predominantly causing a "blank space" between neighboring loops (Fig. 7).

Submucosal smooth-muscle tumors, when seen en face (Fig. 13a), produced a rounded defect completely within the lumen of the bowel, but when viewed tangentially (Fig. 13b), caused a semilunar indentation into the opacified lumen. This semilunar depression was never broader within the lumen than it was at the base. Over the tumor, the mucosal folds were flattened but not destroyed. Adjacent to the tumor, the folds were normal and the pliability of the wall was not altered. If the neoplasm was large in comparison to the lumen of the bowel, its outline could be seen to project outward and displace

neighboring loops in the fashion of the subserosal variety (Fig. 13, c and d).

Dumbbell tumors combined the manifestations of submucosal and subserosal types.

Ulceration of the mucosa over the tumor

occurred rather frequently, and was the cause of the bleeding experienced by these patients. When an ulcer was present, it could usually be demonstrated roentgenologically as a crater (Fig. 14a). Most of

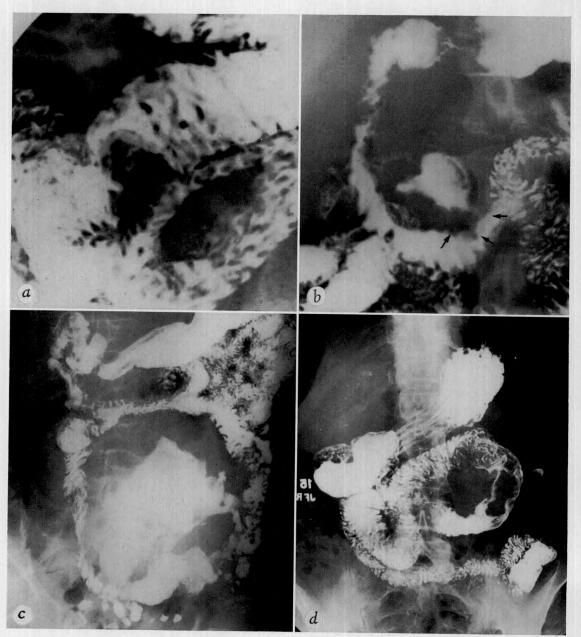


Fig. 14. Four cases of smooth-muscle tumors demonstrating forms of ulceration. (a) Small leiomyoma of jejunum with small niche extending into submucosal mass of tumor. (b) Leiomyosarcoma of duodenum with large excavation into body of tumor. In this case, lesion was extrinsic for the most part and it is difficult to demonstrate its point of attachment to wall of intestine (arrows). (c) Very large leiomyosarcoma displacing neighboring loops of intestine and showing extensive excavation of central portion of tumor. (d) Leiomyosarcoma demonstrating ulceration and fistulous tract into tumor.

these ulcers were single, small, well-defined and round or linear. When large, they extended into the body of the tumor, forming a deep, irregular cavity (Fig. 14, *b* and *c*).

Roentgenologically, it is seldom possible to distinguish between the benign and the malignant varieties of smooth-muscle tumors. Leiomyosarcomas are more likely to be large, to undergo central necrosis and excavation or to exhibit long fistulous tracts extending into the substance of the tumor (Fig. 14d).

Leiomyomas are sometimes multiple, and this fact was demonstrated in one case by roentgenologic examination.

#### ADENOMATOUS POLYP

Sixty-seven patients with adenomatous polyps were included in the series of 659 patients with tumors of the small intestine. In 40 the tumors were found at necropsy and in 27 at surgical exploration. In only 11 patients were clinical symptoms and signs produced; in 7 the tumors were associated with manifestations of intestinal obstruction, in 7 there was evidence of loss of blood, and in 2 a mass was palpable in the abdomen.

Most of the adenomatous polyps occurred singly, but in a few cases they were multiple and were associated with the signs of the Peutz-Jeghers syndrome. In this condition, polyps were scattered throughout the entire gastrointestinal tract and were accompanied by the manifestation of a characteristic pigmentation of the mucosal surfaces of lips and mouth.

Whereas adenomatous polyps of the colon are thought by some to undergo malignant change and to be the precursors of adenocarcinoma, it is believed that those in the small intestine and especially those associated with the Peutz-Jeghers syndrome never become malignant. As a matter of fact, in no case in this series was adenoma of the small intestine associated with malignant change.

Adenomas were encountered in all segments of the small intestine; 21 per cent were situated in the duodenum, 36 per cent in the jejunum and 43 per cent in the ileum (Table III).

For the most part, adenomatous polyps are pedunculated and exhibit the roent-genologic manifestations of an intraluminal defect. Although it is the most common tumor with this gross anatomic form, distinction from other histologic types of intraluminal lesions is not always possible. Adenomas are more likely to be lobulated (Fig. 15c), a fact that may distinguish them from the smoother-surfaced leiomyomas and lipomas.

Because they are pedunculated, they tend to intussuscept (Fig. 15, a and b). If the intussusception can be reduced by manipulation at the time of fluoroscopic observation and the pedicle recognized, the character of the tumor may be suspected. If the intussusception cannot be reduced, the nature of the causative lesion will not be recognized (Fig. 15d).

Roentgenologic discovery of these tumors was rare. Most of those found before surgical exploration were situated in the duodenum and upper jejunum. This is perhaps a commentary on the inability of the roentgenologist to find small intraluminal lesions except in those segments of the bowel most accessible to palpatory manipulation during fluoroscopy.

#### LIPOMA

Fifty-three of the 659 tumors of the small intestine in this series of cases were lipomas. Thirty-two per cent were situated in the duodenum, 17 per cent in the jejunum and 51 per cent in the ileum (Table III). Thirty-four were found at necropsy and 19 at surgical exploration. Only 15 produced clinical manifestations; of these, 13 produced signs of intestinal obstruction, 6 caused loss of blood, 4 were palpable as a mass in the abdomen, and 3 were associated with loss of weight (Table II).

Although lipomas may become pedunculated and exhibit the roentgenologic manifestations of an intraluminal mass (Fig. 16c), most of the tumors in this group were found to be intramural and submucosal

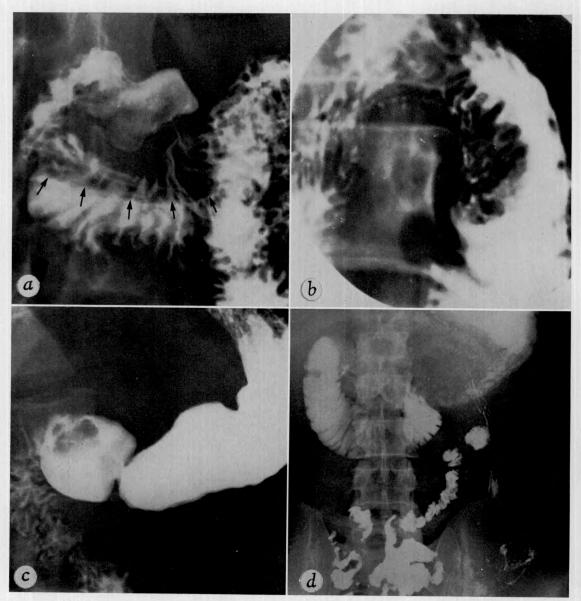


Fig. 15. Three cases of adenomatous polyps. (a and b) Adenomatous polyp on long pedicle (arrows) which was attached to wall of second portion of duodenum (a). The polyp itself is shown in jejunum just beyond ligament of Treitz (b). It could be moved back and forth in bowel by manual pressure. (c) Intraluminal filling defect in first portion of duodenum caused by lobulated adenoma. (d) Intussusception caused by two benign adenomatous polyps of proximal part of jejunum.

(Fig. 16, a and b). In neither instance can an exact histologic diagnosis be made by the roentgenologist, since other tumors, especially those derived from other connective-tissue elements, produce the same roentgenologic features.

Very few of the lipomas were discovered by the roentgenologist, even those that caused symptoms. These few were either in the duodenum, the proximal part of the jejunum or the terminal segment of the ileum (Fig. 16d).

Some lipomas encountered in the colon may be identified roentgenologically. The features that permit such a diagnosis are the relative radiolucency of a submucosal mass and its evanescent character at the time of palpatory manipulation during fluoroscopic observation. These features were never recognized in our cases of lipoma of the small intestine.

#### HEMANGIOMA

Forty-three of the tumors of the small intestine in the Mayo Clinic series were hemangiomas. One was found in the duodenum while 24 were situated in the jejunum and 18 in the ileum (Table III). Only 10 caused clinical symptoms and signs; in 7 instances the patient had experienced passage of black stools, and in all 10 cases the patient was anemic and complained of weakness. In no case was there evidence of intestinal obstruction, loss of weight or pal-

pable abdominal mass (Table 11).

Thirty-three hemangiomas were discovered at necropsy and the other 10 at operation. In no instance was the lesion discovered roentgenologically. Presumably, this was because most of these tumors were small, were situated in a submucosal position and, being made up in large measure of blood, were easily compressed and obliterated by palpatory manipulation.

In 1961, and therefore not included in this series of cases, we had the opportunity to observe and examine a patient with multiple hemangiomas in the stomach, small intestine and colon. Roentgenologically, these small tumors produced rounded filling de-

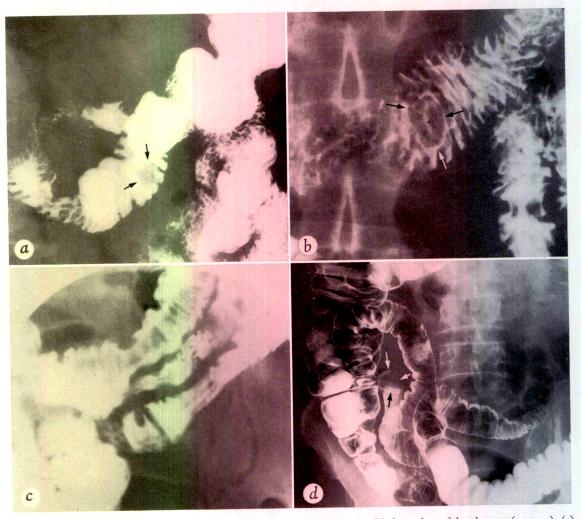


Fig. 16. Three cases of lipoma. (a and b) Small submucosal lipoma in third portion of duodenum (arrows). (c) Long pedunculated lipoma producing intraluminal filling defect. (d) Submucosal lipoma of terminal part of ileum demonstrated by double contrast examination at time of barium enema (arrows).

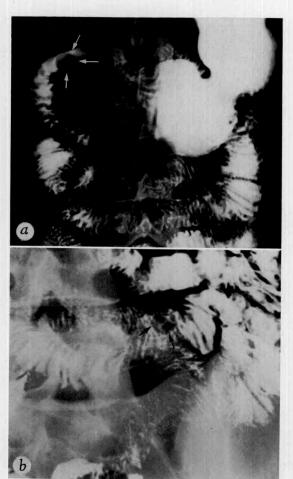


Fig. 17. (a and b) Multiple hemangiomas in duodenum and jejunum (arrows).

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fects not unlike those exhibited by other submucosal tumors. We were able to recognize several of the lesions in the duodenum and jejunum (Fig. 17, a and b).

#### OTHER TUMORS

Fifty of the 659 tumors in this series were not included among those already discussed. Sixteen were lymphangiomas, 11 were fibromas, 5 were adenomas of Brunner's glands, 5 were derived from nerve tissue, 4 were malignant tumors of blood or lymph vessels and 9 were classified among other lesions derived from epithelial and connective-tissue elements. Some produced clinical manifestations; however, many did not, but were discovered incidentally at the time of surgical exploration or necropsy. Twelve were situated in the duodenum, 16 in the jejunum and 22 in the ileum (Table III).

Adenomas of Brunner's glands were found in the duodenum only. Roentgenologically, they could be classified as intra-

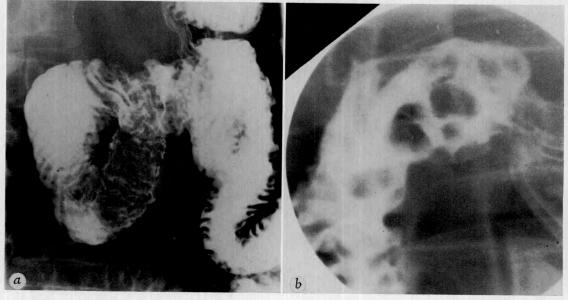


Fig. 18. (a) Intussuscepting pedunculated adenoma of Brunner's glands which arose in first portion of duodenum but was found in third portion. (b) Hyperplasia of Brunner's glands.

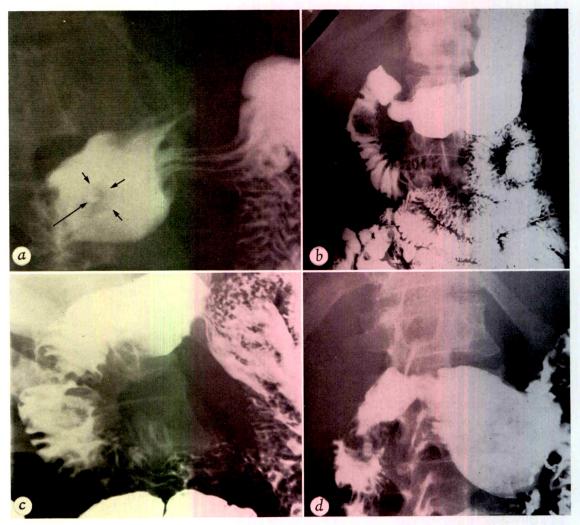


Fig. 19. (a) Aberrant pancreatic tissue in first portion of duodenum. Shadow which resembles crater (long arrow) is caused by barium entering a vestigial duct leading into mass. (b) Enteric cyst in submucosal position in second portion of duodenum. (c) Submucosal neurofibroma in second portion of duodenum. (d) Pedunculated intraluminal ganglioneuroma in second portion of duodenum.

luminal or mucosal (Fig. 18a). Except that all originated in the first portion of the duodenum, they could not be distinguished from other duodenal lesions having the same gross anatomic characteristics. Diffuse hyperplasia of Brunner's glands does produce roentgenologic manifestations that are relatively pathognomonic (Fig. 18b). In such a case, multiple polypoid defects are seen in the duodenal bulb.

Aberrant pancreatic tissue may produce a submucosal filling defect containing a central crater or crypt which is said to be caused by the presence of a vestigial duct that fills with contrast material (Fig. 19a). A similar picture can be produced by a leiomyoma with a small ulcer in the mucosa overlying the tumor.

Enteric cysts and neurogenic tumors caused submucosal, intramural defects (Fig. 19, b and c) or intraluminal polypoid deformities (Fig. 19d) in the opacified lumen of the duodenum which were characteristic only of the gross anatomic form of the tumor and not of a specific entity. For the most part, these lesions could be discovered roentgenologically because of their situation in an easily examined segment of





Fig. 20. Leiomyosarcoma arising in Meckel's diverticulum. Second pouch (lower arrow) was an excavation into tumor.

the small intestine, but could not be identified histologically.

Rarely, a tumor arises in a Meckel diverticulum. Many of the tumors discussed previously have been reported to occur in such a diverticulum. In most instances, these have been encountered at operation or at necropsy. We have observed I case of leiomyosarcoma arising in a Meckel diverticulum in which the presence of the diverticulum was demonstrated roentgenologically before operation, but in which the presence of the tumor was not recognized. What was thought to be a secondary pouch arising from the tip of Meckel's diverticulum proved in reality to be an excavation into the submucosal mass of the tumor (Fig. 20).

#### COMMENT

Despite the rarity of tumors of the small intestine, radiologists should be acquainted with the various histologic types, their incidence and their clinical and roentgenologic manifestations. While examination of the duodenum and proximal portion of the jejunum is not particularly difficult, detailed observation of the distal portion of the jejunum and the ileum may require considerable time. The radiologist must find the lesion before he can attempt to identify it. Once found, close attention to gross anatomic form and position is necessary in

order to make a proper diagnosis.

My own experience indicates that fluoroscopic observation is essential in many cases. If possible, the opacified lumen should be studied in continuous fashion, preferably at a time when the loop under observation is distended by the passage of a peristaltic wave. Complete examination requires several periods of study at intervals of 30 to 45 minutes. The more rapid the transit of opaque material from duodenum to cecum, the better the examination and the less time it takes. I have found it helpful to express manually into the duodenum as much of the barium suspension as possible at the time of the first observation. After this, the patient is given more of the mixture to drink and is asked to lie on his right side. A second fluoroscopic observation is made at the end of 30 minutes and others at intervals 30 to 45 minutes thereafter until the cecum is reached and identified. The bowel is traced, manipulated and studied as completely as possible from pylorus to ileocecal valve, care being taken to resume the examination from the point at which it was discontinued at the preceding session. An attempt is made to observe each loop in its distended state and then to compress it manually in order not to overlook small intraluminal or submucosal masses.

Once a lesion is discovered, attention must be paid to form and position in relation to the lumen. Careful manipulation and study will distinguish the intraluminal. mucosal and submucosal varieties and will identify areas of ulceration. Recognition of these features will serve to identify certain histologic types, or to exclude the possibility of varieties that do not exhibit these features.

One must remember that the ability of

the radiologist to discover and identify tumors in the small intestine is much less than it is in the esophagus, stomach or colon. A negative examination does not always mean that the presence of a neoplasm has been excluded. Knowledge of this fact keeps us humble, but should spur us on to more careful and thorough observations of this portion of the gastrointestinal tract.

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## BLIND POUCH FORMATION SECONDARY TO SIDE-TO-SIDE INTESTINAL ANASTOMOSIS\*

By MILTON LEVINE, M.D., ISADORE KATZ, M.D., and PETER J. LAMPROS, M.D. BROOKLYN, NEW YORK

BLIND pouch formation following sideto-side intestinal anastomosis is well known to surgeons but little has appeared in the roentgenologic literature about this not infrequent postoperative complication. The paper of Senturia and Heifetz40 published in 1952 represents the sole comprehensive work dealing with the roentgen diagnosis of this lesion. Although side-toside anastomosis is not as commonly used as end-to-end anastomosis as a method of re-establishing bowel continuity, it is still being performed. The continued occurrence of blind pouches is therefore to be expected. In view of the dramatic relief of acute and chronic symptoms which follows surgical correction of this condition and the occasional fatal outcome in undetected cases, recognition of the presence and significance of a blind pouch is an important responsibility of the roentgenologist. Eleven new cases are reported in this paper.

#### HISTORY

The high mortality (30-50 per cent) following end-to-end intestinal anastomosis prompted Ashton and Baldy2 in 1891 and Küttner<sup>27</sup> in 1896 to advocate the use of side-to-side anastomosis although they were aware that blind pouches might form in the blind distal end of the proximal anastomotic segment. In animal experiments Senn<sup>39</sup> had previously demonstrated that there was frequent stagnation of intestinal contents in a blind pouch. This was thought to be due to an inadequate anastomotic opening. Bayliss and Starling4 in 1899 and Cannon and Murphy9 in 1907 concluded that division of the circular muscle fibers of the intestine, occurring during the creation of a side-to-side anastomosis, interfered with the passage of bolus and resulted in stasis and pouch formation. They also felt that similar stasis occurred in the regional lymph channels and venules. Cannon and Murphy<sup>9</sup> based many of their conclusions on fluoroscopic observations of the behavior of experimentally created side-to-side anastomosis in cats.

These observations on experimental animals were reflected in a revival of the more physiologic end-to-end anastomosis while many reports over the ensuing decades continued to point out the hazards of pouch formation following side-to-side anastomosis.3,6,7,12,13,19,21-24,34,35,38,43 opinion holds that pouch formation is not frequent enough to warrant discontinuation of the usage of side-to-side anastomosis although end-to-end anastomosis is preferable when conditions permit.36 Side-to-side anastomosis is still considered a "safe, simple and effective technique"14 and it is favored by some because the stoma can always be made of ample size.5 However, it is generally recognized that as a safeguard against pouch formation the distal portion of the proximal segment should be made as short as is technically feasible.

#### PATHOGENESIS

The blind pouch does not occur in end-to-end or in end-to-side intestinal anasto-moses. The portion of the intestine which forms the blind pouch is invariably the short length of proximal bowel which lies beyond the stoma, whether the anastomosis involves only small bowel, small and large bowel, or only large bowel<sup>40</sup> (Fig. 1). The phenomenon of pouch formation was studied fluoroscopically by Pearse<sup>34</sup> in 60 dogs in which blind pouches of various lengths had been created. He noted that barium entered the blind pouch as a result

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of propulsion by peristaltic waves and that dilatation of the pouch increased as peristalsis continued. With cessation of peristalsis the barium flowed back through the loop whereupon the dilated blind end resumed its former size. Pearse<sup>34</sup> observed no evidence of reverse peristalsis in this process but rather that the flow of the barium back from the blind end appeared to be the result of its elastic contraction. Some of the barium was then noted to spill through the anastomotic opening into the distal anastomotic segment. He felt that this explained removal of the fluid content of the blind loop and retention of the solid material.

These findings were confirmed by Ginzburg and co-workers<sup>19</sup> in a report of 32 cases of ileocolostomy with exclusion in humans. Barium contrast study of 22 of these patients showed that dilatation occurred only in the blind end of ileum used in side-to-side anastomosis. They also noted that although there was retrograde passage of ileal contents into the excluded segment of colon, there was no dilatation or ulceration of the bypassed colonic segment.

Pearse<sup>34</sup> further concluded from his animal experiments that distal blind portions of the proximal anastomotic segment measuring I foot or less in length apparently emptied themselves and so did not become dilated. Distal segments of 2 or more feet were observed to become dilated and to fill with inspissated material. His observations covered a period of I year after operation. Pollock,36 on the other hand, observed a patient in whom the closed end of the ileum extended only 3/4 of an inch beyond the stoma at the time side-to-side ileocolostomy was performed. Thirteen years later a blind pouch 5 inches in length and 3 inches in diameter was found at surgery. Estes and Holm<sup>13</sup> reported an instance of side-to-side ileocolostomy in which a 4 inch distal blind segment of ileum was left. Ten weeks later this pouch "filled the lower half of the abdominal cavity" and measured 18 inches in length and 3 to 4 inches in diameter.

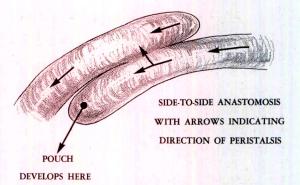


Fig. 1. Blind pouch formation secondary to intestinal side-to-side anastomosis.

In animal experiments, Eckel and Holman<sup>12</sup> found that if isoperistaltic ileocolostomy was performed the blind segment of ileum was less likely to fill with intestinal contents than if an antiperistaltic anastomosis was done. Pollock's case of blind pouch mentioned above was an isoperistaltic side-to-side ileocolostomy.

Although the initial length of the proximal blind segment and peristalsis may be important in pouch formation, intestinal tone and nerve fiber hypertrophy may also be of significance.<sup>36</sup>

#### SYMPTOMS

It is difficult to estimate the frequency with which blind pouches produce symptoms. Hypertrophy and elongation of blind loops of ileum have been observed incidentally at autopsy years after resection of the colon with ileocolostomy and side-toside anastomosis.38 Pickhardt35 reported a case of blind pouch which was asymptomatic. Black and McEachern<sup>6</sup> stated that they had noted repeatedly at the second stage of two-stage right colon resections that "redundancy" had developed in the distal portion of the proximal small bowel segment. They questioned the need for routine resection of this segment. Senturia and Heifetz40 felt that the majority of blind intestinal pouches go unrecognized because they are asymptomatic. However, in most of the reported cases exhibiting symptoms, the patients complain of abdominal cramps and borborygmi, nausea and vomiting,

distention, diarrhea which is frequently intermittent, weakness and fatigue and inability to gain weight. The symptoms may resemble intestinal obstruction. A palpable mass is often found. The pouches may ulcerate,13 bleed 36 or perforate.6,43

Anemia may or may not be present with blind pouches. When anemia is present, it is frequently of the macrocytic type. The mechanism of production of macrocytic anemia is presumably similar to that in intestinal strictures and small bowel diverticulosis. In 1897 Faber<sup>15</sup> reported necropsy proof of macrocytic anemia associated with a distal jejunal stricture in a young woman. By creating blind intestinal pouches and strictures in dogs, Horster<sup>25</sup> produced anemias. Cameron et al.8 produced macrocytic anemia in rats by creation of blind pouches. Their studies suggested "that the decisive event may be a change in the flora of the loop and possibly, in the remainder of the intestine. This may lead to the loss of an organism which synthesizes hemopoietic material, or the preponderance of an organism which uses up hemopoietic material, or the presence of an organism which produces an antagonist to hemopoiesis." The anemia in these rats responded to liver extract and pterylglutamic acid.

Lichtman et al.31 treated 4 patients with Addisonian pernicious anemia in relapse with an intestinal antibiotic with definite, albeit incomplete, hematologic improvement. They concluded that this approach had either removed hemolytic toxin through intestinal sterilization, eliminated E. coli or other bacterial organisms which have been demonstrated to have an exceptionally high affinity for vitamin B1211 or allowed the overgrowth of yeasts and other microorganisms which in turn may produce pterylglutamic acid or other hematopoietically active substances utilizable by the patient. 18,41 Macrocytic anemia associated with a blind pouch can be distinguished from Addisonian pernicious anemia by use of the Schilling test.37

With surgical correction of the blind pouch, the anemia disappears.

#### ROENTGEN FINDINGS

History of a previous intestinal resection should alert both clinicians and roentgenologists to the possible existence of a blind pouch and should indicate the need for

appropriate barium studies.

On the plain roentgenogram of the abdomen, a blind pouch may be manifested in a variety of ways. In all of our patients a gas-filled structure of variable size and shape, occasionally resembling distended intestine, was seen. This gas-containing structure was either elongated, tubular or club-shaped. If seen face on, it appeared as a spherical air-containing cystic structure. If filled with intestinal fluid, it resembled a soft tissue mass (Fig. 2B and 12B). Intestinal obstruction may be simulated (Fig. 9A). In the 2 children studied, the air-filled pouches appeared relatively larger than those found in adults.

Variability in size and shape of the pouch in the same individual may also occur. Filling defects are commonly present within the barium-filled pouch and are caused by intestinal debris. The pouch will usually become opacified with barium despite the presence of intestinal contents. When the barium-filled pouch is spherical (Fig. 2C; 3B; and 8), with or without demonstration of a narrow neck, we feel the appearance is

distinctive.

The differential diagnosis on roentgenograms of the abdomen must include any large collection of gas or fluid in various diverticula or intestinal obstructions or extra-intestinal fluid or fat collections. 1,5,10,16,17,28,29,30,32,33,42,44 A barium-filled Meckel's diverticulum may simulate a surgically created blind pouch. However, a typical gastric rugal pattern may be demonstrated in Meckel's diverticulum.26 Barium-filled bowel duplications must also be differentiated from blind pouches.20,45 History of a previous side-to-side intestinal anastomosis should serve to dis-

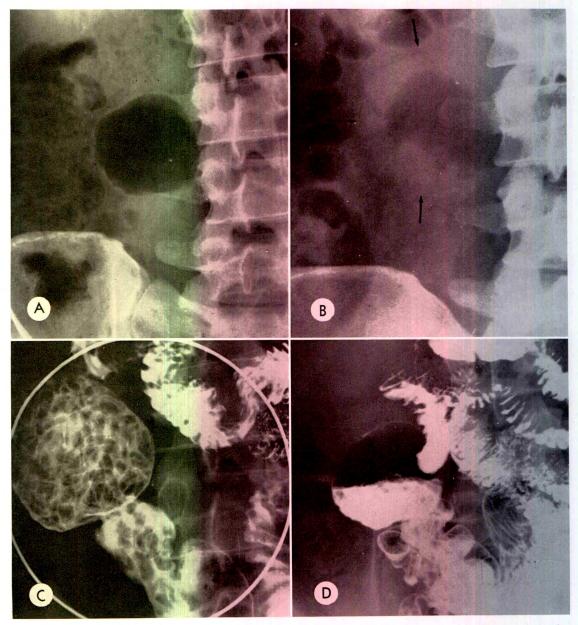


Fig. 2. Case I. (A) The discrete, rounded, gas-containing structure visualized to the right of the lumbar spine at the level of L 3 represents the blind pouch in the proximal segment of the distal ileal anastomosis (plain roentgenogram, recumbent). (B) The pouch is visible in the same areas as a globular soft tissue density when it is filled with fluid (arrows). There is a radiolucent central area indicating gas on the surface of the fluid (recumbent). (C) Detail study of barium filled blind pouch in the distended state (gastrointestinal series). The pouch is spherical and has a narrow neck. This is a distinctive appearance (see Fig. 3B and Fig. 8). The filling defects were produced by small fecal masses of the consistency of putty, measuring approximately I cm. in diameter. No barium has as yet passed through the stoma to enter the distal segment of the anastomosis. (D) Barium-filled pouch in the right lower quadrant (erect position) shows layering of air-barium mixture.

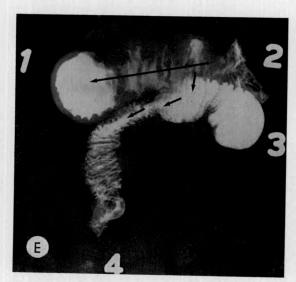


Fig. 2. (E) Roentgenogram of the resected surgical specimen opacified with barium. The blind pouch, point 1 in the specimen, is only mildly distended since its elasticity was preserved. The open end, at the line of resection of the proximal segment, is at point 2. The blind end of the distal segment is at point 3. The open end at the line of resection of the distal segment is at point 4.

tinguish all of the above from a blind pouch.

## REPORT OF CASES

Case I. A 31 year old white male developed intestinal obstruction due to volvulus of the ileum in 1945. The volvulus was reduced at laparotomy but no resection was done. Two months later he had intestinal obstruction due to adhesions. Twelve inches of gangrenous ileum were resected and a side-to-side ileoileostomy was done. In 1946 a small bowel study revealed "segmented dilatations of the ileum," especially in the right upper abdominal quadrant "where one segment is enormously dilated." Since the second operation, the patient had had intermittent bouts of abdominal cramps and diarrhea. In 1957 the cramps became more severe and finally he required hospitalization. In the 6 months prior to admission the patient lost 10 pounds of weight. His hemoglobin was normal. Gastrointestinal studies revealed "a picture suggestive of either Meckel's diverticulum or a post-surgical abnormality such as a blind loop secondary to the side-to-side anastomosis" (Fig. 2, A-D). He developed signs and symptoms of low grade intestinal obstruction while in the hospital and a

laparotomy was done. A distended blind pouch of the distal end of the proximal anastomotic segment was resected (Fig. 2 E). The ileoileostomy stoma was found to be barely probepatent. The patient's complaints disappeared postoperatively.

CASE II. This 41 year old white male had the onset of severe abdominal cramps and diarrhea in 1946. In 1952 a diagnosis of regional ileitis was made and a segment of ileum was resected. A side-to-side ileoileostomy was performed. He remained well until 1957 when he developed abdominal cramps, flatulence, abdominal distention and constipation alternating with diarrhea. No mucus or blood was noted in his stool. His hemoglobin was 12.8 gm. A small intestinal examination revealed a distended loop of terminal ileum consistent with a blind pouch secondary to a side-to-side anastomosis (Fig. 3, A and B). This was confirmed at laparotomy. Resection of the blind pouch and an end-to-end anastomosis were performed. The ileoileostomy stoma was found to be patent. There was no evidence of regional ileitis at the second operation. The patient was asymptomatic following surgery.

Case III. This 68 year old white male was hospitalized with complaints of anorexia, weakness, anemia, abdominal pain and diarrhea. Seven whole blood transfusions had been given in the 2 months prior to admission. On admission his hemoglobin was II.5 gm. He had had a resection for carcinoma of the ascending colon in 1956 with a side-to-side ileocolostomy. A barium enema study on September II, 1958 showed a blind ileal pouch at the ileocolostomy site (Fig. 4). The patient refused further surgical treatment.

Case IV. This 63 year old white male had an appendectomy in 1953. This was followed by intestinal obstruction treated by bowel resection and side-to-side small bowel anastomosis. He was seen in 1958 at which time there were complaints of several weeks of abdominal cramps, diarrhea, anorexia and a 10 pound weight loss over the previous month. His hemoglobin was 13.8 gm. A blind pouch was noted on the  $2\frac{1}{2}$  and 24 hour roentgenograms of a gastrointestinal series (Fig. 5,  $\mathcal{A}$  and  $\mathcal{B}$ ). No corrective surgery was done.

Case v. A 79 year old white male had a right hemicolectomy and side-to-side ileocolostomy

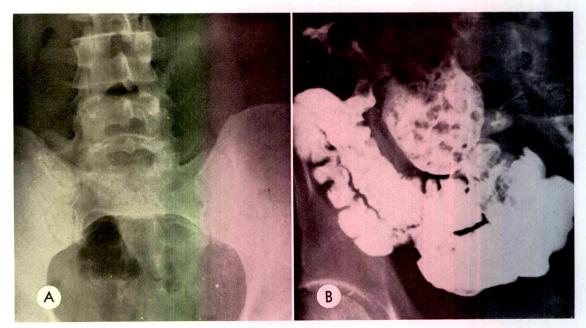


Fig. 3. Case II. (A) Erect study of abdomen shows an isolated, gas-containing structure in right lower quadrant within which is an air-fluid level. The absence of gas elsewhere in the abdomen suggests a stagnant or obstructed loop or pocket. (B) Distended blind end of proximal segment of the lateral ileoileal anastomosis filled with barium during a gastrointestinal examination. Filling defects within pouch are due to feces. This pouch is identical in roentgen appearance with the one seen in the previous case (Fig. 2C) except that the narrow neck is not seen. There is also a similarity between these pouches and the one seen in Case VII (Fig. 8).

in 1947 for carcinoma of the cecum. He was well until 1957 when he noted mild intermittent cramps, distention and nausea. There was no vomiting, diarrhea or anemia. A blind ileal pouch was visualized on a barium enema study (Fig. 6). Because of the mildness of the patient's symptoms, surgical treatment was not considered. The patient had no significant bowel complaints when seen 2 years later.

Case VI. This 33 year old female was referred to the hospital hematology clinic in February, 1959 with a diagnosis of Addisonian pernicious anemia. The diagnosis was made on the basis of a bone marrow aspiration done in December, 1958. This was repeated and the

findings were confirmed in April, 1959. In 1942 she had had a perforated appendix which was treated with cecostomy, followed by a cecectomy and a side-to-side ileotransverse colos-

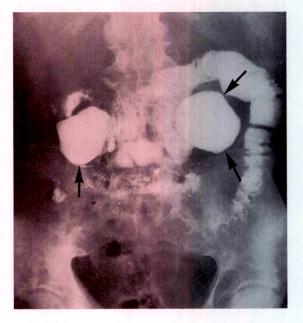


FIG. 4. Case III. Two barium-filled distended pouches are demonstrated by barium enema in a patient who had a right hemicolectomy and side-to-side ileocolostomy for carcinoma of the ascending colon 2 years prior to this examination. The pouch seen to the patient's left represents the blind ileal pouch (arrows), whereas the one to the patient's right is the blind end of the colon (single arrow).

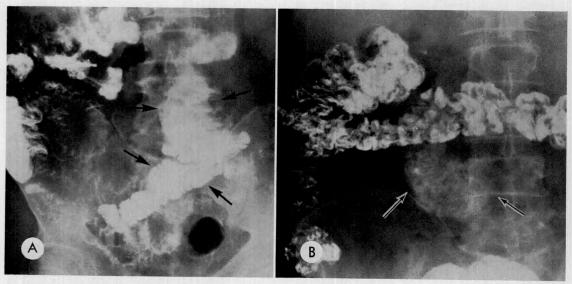


Fig. 5. Case IV. (A) The  $2\frac{1}{2}$  hour interval roentgenogram of a serial barium study of the small intestine reveals a markedly distended segment of small intestine in the mid-abdomen (arrows). Note the density of barium in this pouch and the more dilute barium in the terminal loops of ileum. The ascending and proximal transverse segments of colon are filled and in these the barium is equal in density to that in the pouch. (B) The 24 hour roentgenogram of the serial study reveals that all of the orally ingested barium is in the colon with the exception of a small quantity which is retained in the pouch seen at the inferior aspect of the transverse colon (arrows).

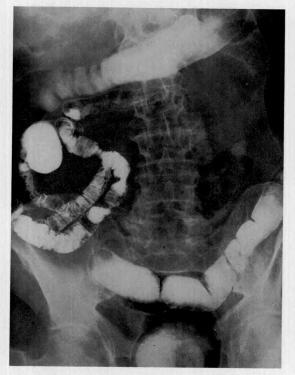


Fig. 6. Case v. Barium enema study following right hemicolectomy and side-to-side ileocolostomy reveals a blind ileal pounch in the right flank.

tomy. Since that time, the patient had had complaints of intermittent diarrhea and abdominal cramps. No blood was noted in the stool and there was no palpable abdominal mass. The anemia was treated at various times with diet, iron, transfusion and vitamin B12 injections. The hemoglobin varied from 4.0 to 8.0 gm. during 2 months of observation in the clinic. A 24 hour Schilling test in April, 1959 prior to surgery showed a normal absorption of 90 per cent. Barium studies showed a large blind pouch of ileum (Fig. 7, A and B). She was prepared for surgery with transfusions, the old anastomosis was revised and an end-to-end ileocolostomy was done. Approximately a year later, the patient was working regularly and had no complaints of any kind.

Case VII. This 58 year old male was hospitalized in 1959 with complaints of intermittent abdominal pain, nausea, vomiting and constipation. His hemoglobin was 6.0 gm. He had had a right hemicolectomy for a colonic carcinoma in 1951. At the time of this last admission, he had a small bowel series which demonstrated a blind pouch in the region of the ileotransverse colostomy (Fig. 8). A laparotomy was done and the diagnosis was confirmed but

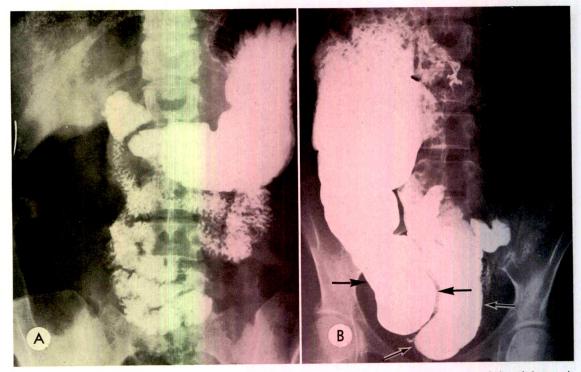


Fig. 7. Case vi. (A) A huge gas-containing blind pouch occupying the entire right side of the abdomen is noted on an upper gastrointestinal examination. (B) Barium enema study reveals the pouch which has developed in the ileal segment of a side-to-side ileotransverse anastomosis (black arrows). Neighboring barium-filled, overlapping loops of pre-anastomotic ileum are also noted (white arrows).

corrective surgery was not performed because of tumor recurrence.

Case VIII. This 67 year old white female had a resection for carcinoma of the descending colon in 1943. Subsequently she developed intermittent abdominal pain lasting I to 2 days and vomiting. A mass was palpated in the left lower abdominal quadrant. Her hemoglobin was 13.9 gm. A barium enema study showed a blind pouch of colon (Fig. 9, A and B). In May, 1960 she had surgery at which time a large blind pouch was found resulting from a previous sideto-side transverse-descending colostomy. There was no evidence of a recurrence of carcinoma. The area was resected and an end-to-end anastomosis done. The patient has been asymptomatic to date.

Case IX. This 19 month old white female twin was born on July 13, 1959 weighing 6 pounds, 6 ounces. Abdominal distention was noted shortly after birth. No meconium was passed. Roentgen study of the abdomen indicated a jejunal atresia with possible meconium

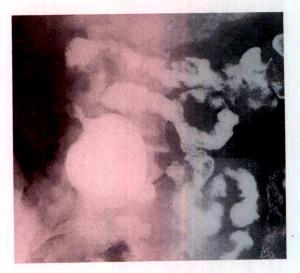
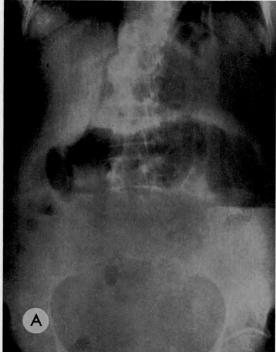


Fig. 8. Case VII. A small intestinal examination outlines a blind pouch which has developed in the ileum following a side-to-side ileotransverse colostomy with resection of the ascending colon performed 8 years earlier. Note the spherical appearance and narrow neck as in Fig. 2 C and the similarity to Fig. 3 B.



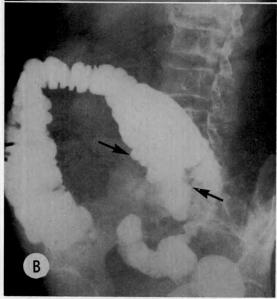


Fig. 9. Case VIII. (A) Erect roentgenogram of the abdomen shows a distended segment of bowel with an air-fluid level in the left portion of the segment. This is the site of a palpable "mass." This blind pouch developed following a side-to-side transverse-descending colostomy performed 17 years earlier for carcinoma. (B) Roentgenogram of colon made in the right oblique position reveals the barium filled pouch which has formed in the transverse colonic segment.

peritonitis. The distention became worse and a laparotomy was done within 24 hours after birth. At surgery small bowel volvulus was found along with a jejunal atresia and jejunal perforation. Approximately 16 cm. of jejunum was resected and a side-to-side anastomosis was done. The patient did well postoperatively and was discharged home, to be re-admitted on August 26, 1959 for diarrhea, dehydration and malnutrition. The hematocrit on admission was 26. The patient was transfused with whole blood, fed intravenously and subsequently was able to tolerate feedings, did well and was discharged on November 17, 1959, weighing approximately 7 pounds and 11 ounces. Fifteen months later, at the age of 19 months, the child was thriving and weighed 24 pounds and was apparently asymptomatic. At the same time the twin weighed 24 pounds. Roentgen study of the small bowel done on November 15, 1960, as a routine follow-up, demonstrated a large blind pouch of jejunum (Fig. 10, A and B). Corrective surgery was not done.

Case x. A 3 day old white male infant was admitted for the first time in June, 1953 for vomiting since birth. At laparotomy, performed on the day following admission, a 3 cm. area of atresia of the mid-jejunum was found and resected. A side-to-side anastomosis was done. The patient had a stormy postoperative course and because an anastomotic leak was suspected a second laparotomy was done. Perforation of a gangrenous segment of jejunum with widespread peritonitis was found. This jejunal segment, measuring 15 cm., was resected and again a side-to-side anastomosis was done.

In the ensuing 18 months, the patient was hospitalized on several occasions for intestinal complaints. Nine months after the original surgical procedure gastrointestinal studies revealed a large small intestinal blind pouch which retained barium for 24 hours (Fig. 11). The findings were not recognized as the result of side-to-side anastomosis. He was discharged without a definitive diagnosis and referred to the out-patient department for continued observation. The patient was not seen for followup study for 3 years. He was returned at that time because of weight loss, diarrhea, bulky, foul-smelling stools, intermittent abdominal cramps and "bloating." The abdomen was protuberant and the lower extremities were spindly and wasted. A diagnosis of malabsorption syndrome was made and despite medical

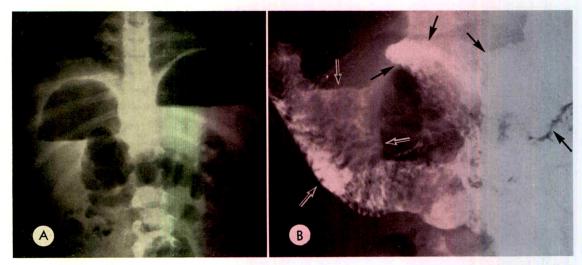


Fig. 10. Case IX. (A) Erect roentgenogram of the abdomen in an asymptomatic 19 month old female who had had a side-to-side anastomosis for jejunal atresia 24 hours after birth. The fluid level in the left upper quadrant is within the gastric fundus. The fluid level in the right upper quadrant is within the distended blind pouch of the proximal segment of the jejunal anastomosis. (B) A gastrointestinal study reveals the stomach and duodenum in the left upper abdomen (black arrows). The markedly distended blind pouch (white arrows) occupies most of the right side of the abdomen. Note the fluid level (vertical arrow). Gas above this level also lies within the blind pouch.

therapy there was little improvement in the patient's condition. In 1961, 8 years after the roentgen abnormalities were first observed, the condition was finally recognized as a blind pouch secondary to side-to-side anastomosis. To date there has been no attempt at surgical correction.

Case XI. This 40 year old white female was admitted in October, 1938 for abdominal cramps, pain, nausea, vomiting and a weight loss of 27 pounds over a period of 2 months. At laparotomy a partially obstructing lesion in the lower ileum was found. There were two localized areas of thickening of the wall of the small intestine which appeared neoplastic. The mesenteric lymph nodes in this area were enlarged and firm. Two feet of ileum, including both lesions, were resected and bowel continuity was restored with a side-to-side anastomosis. Pathologic diagnosis was "malignant follicular lymphoblastoma." Postoperatively roentgen therapy was administered to the abdomen.

Study of the small intestine made I month postoperatively revealed a blind pouch. It was noted to change in shape and position on different studies (Fig. 12, A–D). Barium was retained in the pouch up to 24 hours after the barium meal. This patient has been followed for

23 years and has no signs or symptoms referable to her gastrointestinal tract. Her hemoglobin has varied between 9 and 11 gm. during this time.



Fig. 11. Case x. A large blind pouch (arrows) in patient at the age of 9 months. A side-to-side jejunojejunostomy was done for jejunal atresia when the patient was 4 days old.

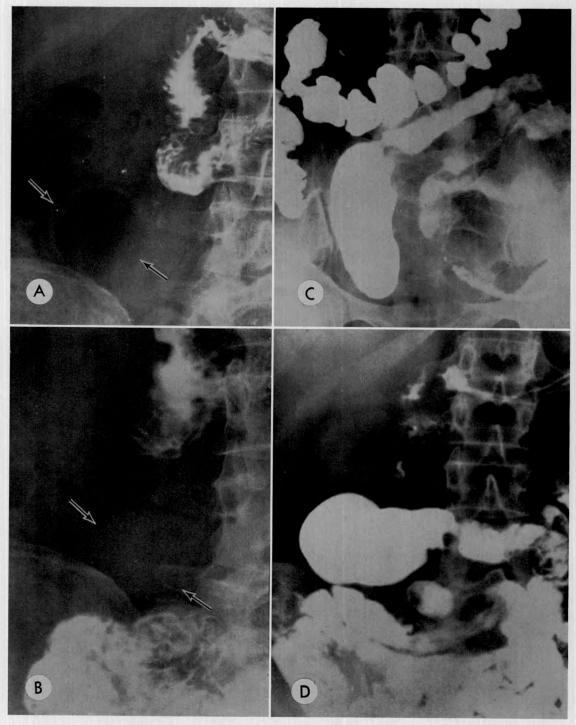


Fig. 12. Case XI. (A) The globular gas collection in right lower quadrant represents a blind pouch seen "end-on" (arrows). (B) A globular soft tissue shadow in the same area depicts the pouch filled with fluid (arrows). (C) Serial study of the small intestine demonstrates the apparently changed shape of the pouch. It is now seen as an elongated "gourd-like" structure in the right presacral area. (D) Study on another occasion reveals the pouch in a different position, demonstrating mobility.

## DISCUSSION

When a blind intestinal segment in a side-to-side anastomosis distends beyond its immediate postoperative site, a blind pouch is said to have formed. A blind loop refers to a segment of bypassed bowel which has become occluded at one end.

It is not certain why the blind segment of the proximal loop which lies distal to the anastomosis distends in some instances and not in others to form a blind pouch. The initial length of this blind segment is probably the most important factor; the longer this segment, the more likely a blind pouch will form. A small segment, however, does not obviate formation of a blind pouch. This was shown by Pollock's<sup>36</sup> case where the initial segment was  $\frac{3}{4}$  of an inch long. Evidence that antiperistaltic side-toside anastomosis is more conducive to pouch formation than an isoperistaltic anastomosis is not convincing. Likewise, proof of the significance of intestinal tone and nerve fiber hypertrophy in pouch formation is lacking. Distention does not occur in the blind segment of the distal anastomotic loop and so a blind pouch does not form here.

We have seen pouch formation as early as I month following the side-to-side anastomosis (Case XI). Others are not detected clinically for several years following surgery. It is uncertain as to the point at which the condition becomes symptomatic.

The age of the patient apparently has no etiologic significance. Our Case x was shown to have a large blind pouch at 9 months of age and Case IX at 19 months of age. Our oldest patient (Case v) was 79 years of age when he first noted symptoms. He had had an intestinal anastomosis at the age of 69.

Eight of our II cases had significant symptoms related to the blind pouch. Four had corrective surgery and all of these were asymptomatic when last seen. One of these 4 had a macrocytic anemia. This cleared following surgery.

Six of the 8 symptomatic patients complained of intestinal cramps and 6 of diarrhea. Other complaints were weight loss, abdominal pain, anorexia, nausea, vomiting, distention and constipation. An abdominal mass was palpable in only 1 of our series. One of our asymptomatic patients has been followed for 23 years (Case XI).

#### SUMMARY

1. Blind pouch formation occurs following side-to-side but not after end-to-end or end-to-side intestinal anastomoses. Our cases have followed jejunojejunostomy, ileoileostomy, ileocolostomy and colocolostomy. Eleven cases are presented.

2. Plain roentgenograms of the abdomen frequently demonstrate the pouch as a spherical, tubular or club-shaped air-containing structure. When filled with fluid or food debris, it may resemble a soft tissue mass. Air fluid levels may be demonstrated within the pouch on upright roentgenograms. The pouches can be opacified by appropriate barium studies, demonstrating the variability of their shapes and positions.

3. Symptoms when present include abdominal cramps, distention simulating intestinal obstruction and intermittent diarrhea. The pouch may be palpable as a soft tissue mass. Anemia may be associated and, on occasion, it is macrocytic in type.

4. Revision of the side-to-side anastomosis with substitution of end-to-end bowel continuity is curative in symptomatic cases.

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## THE ROENTGENOLOGIC PATHOLOGY OF SO-CALLED PNEUMATOSIS CYSTOIDES INTESTINALIS\*

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CPONTANEOUS inflation of the visceral O fascia by air has been recognized for more than 200 years, and the ultimate spectacular ballooning in intestinal coats has been recorded as "pneumatosis cystoides intestinalis." Most authors concentrate exclusively upon this facet as a supposed "primary" lesion. Yet from the earliest literature gas cysts have been described also beneath parietal peritoneum. Besides intestinal emphysema, gas cysts have been reported bloating greater and lesser omentum, mesenteries and their lymph nodes. peritoneum of the liver and gallbladder, more significantly beneath parietal peritoneum of kidneys and lesser pelvis, and even in vaginal walls and in inguinal canals.14

Retention of the term "pneumatosis cystoides intestinalis" conferred a hypothetical intestinal nature on the condition despite failure to show perforative, bacterial or chemical sources of origin. Nevertheless, attention has been forced to remain focused on the abdominal variety, for the usual autopsy technique of elevating the sternal chest wall produces air bubbles in every mediastinum. This leads to pitfalls even for competent pathologists. For example, Masson<sup>10</sup> noticed the flattened cellular lining of abdominal cysts, then, despite the fact that they ranged in diameters up to several centimeters, decided that the gas must lie in distended "lymphatic channels." The true incidence of the condition is uncertain, but radiologic,3,7 and pediatric sources suggest strongly that it is common. The abdominal form is usually asymptomatic for reasons related below, while the thoracic form may be lethal.

A histochemical study of the lining cells of cysts of our 3 cases showed that they were not lymphatic endothelium, but syncytial phagocytes of repair. These observations are reported to show that abdominal emphysema is a decompression of tension pneumomediastinum. Because the arrangement of the fascial compartments in the cervical outlet of thorax tends to block decompression towards the neck, the thoracic pump has a directional bloating effect. Air follows the distribution of fascial sheaths around the aorta and its branches. Bubbles are thus seldom connected laterally, but may be arranged in segmental skip fashion. Air causing serosal ballooning may leak to produce characteristic pneumoperitoneum without peritonitis. As the phenomenon is most often associated with vomiting in cases of pyloric stenosis, silent leakage from a peptic ulcer is the most frequent roentgenologic misdiagnosis. This was true in one of the cases presently reported.

## REPORT OF CASES

Case 1. The patient was a 37 year old female with a 5 year history of hunger dyspepsia and recurrent hematemesis. She complained of epigastric pain, severe vomiting, and moderate hematemesis, but she had also noticed a rapid distention of her abdomen during the previous 2 days. A huge pneumoperitoneum was seen on roentgenograms which was interpreted as "consistent with a ruptured viscus" with "probable perforation." This finding remained unchanged for more than 3 weeks. Clinically, no peritonitis had been noted. A review of the roentgenograms also showed a pneumomediastinum, an encysted effusion into the lesser sac of the peritoneum, and a classic picture of cystic pneumatosis (Fig. 1 to 4). Some months later the patient

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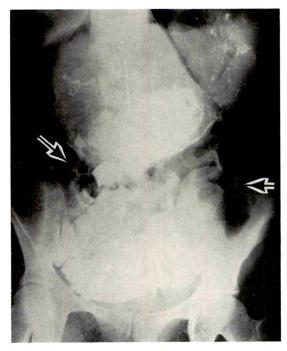


Fig. 1. Case 1. A massive pneumoperitoneum is present with a double contoured intestinal wall on the right (long arrow) and a thin walled pneumocyst (short arrow), probably subserosal, on the left in displaced intestine.

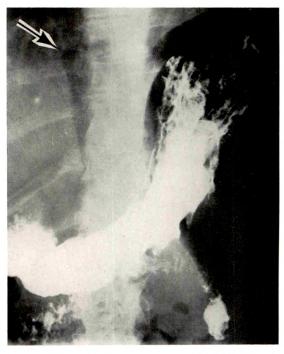


Fig. 2. Case I. A band of paravertebral air shadow (arrow) extends inferomedially on the right between D9 and D12. Gastric barium contrasts with pneumoperitoneum.

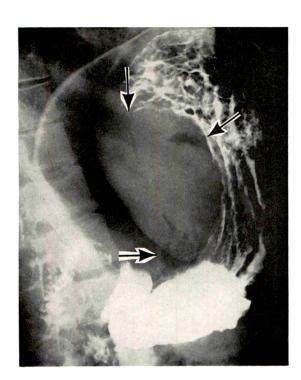




Fig. 4. Case i. Left lateral decubitus position. Thin walled pneumocysts are present on the left (left arrow) and a double contour ring shadow projects in the pelvis on the right into a pneumoperitoneum (right arrow).

Fig. 3. Case I. An encysted effusion in the lesser sac forms an egg shaped density, displacing the stomach laterally. Linear gas streaks radiate (arrows) along the lesser curvature in distributions similar to the branching of the celiac axis, suggesting the large anastomotic loop.

complained of the passage of tarry stools, and secondary signs of peptic ulceration were seen roentgenographically. At laparotomy -wo chronic peptic ulcers were found on the midposterior gastric wall. Partial gastrectomy revealed that the lesser sac was fused by old adhesions. No pneumatosis was detected on gross examination, but microscopically evidence of this was present in the gastric submucosa (Fig. 5). None of the patient's complaints have recurred.

CASE II. The patient was a 75 year old male with a 7 year history of coccydynia and marked constipation, for which no cause had been noted on repeated examinations, including cystoscopy and sigmoidoscopy. The last sigmoidoscopy, however, showed a "polypoid growth" at 20 cm. On review of the bar um enema studies, intramural gas bubbles scal oping one segment of the sigmoid colon (Fig. 6), filling defects of the sigmoid segment (Fig. 7), and gas bubbles in the wall of a segment of the sigmoid loop (Fig. 8) were detected. Bicpsy showed a cyst-like space external to the muscularis, and lying beneath normal mucosa. Around the wall of the cavity were flattened syncytial cells, with occasional multinucleated forms lying apparently free. These were mistakenly interpreted as "signet ring" carcinoma cells lying in tumor mucin with submucosal infiltra-



Fig. 6. Case II. Lozenge shaped intramural gas bubbles scallop one segment of the sigmoid colon.

tion. At laparotomy multiple polyps could be felt in the sigmoid and the lower descending colon, but no other changes were found. This segment was resected (Fig. 9 and 10) and an end to end anastomosis was carried out. Microscopic examination of the resected colon (Fig. 11–13) showed various stages of cystic pneumatosis. Chest roentgenograms showed no abnormalities immediately prior to operation and the condition has not recurred in a one year follow-up.

Case III. This patient was a 72 year old male with congestive heart failure with auricular

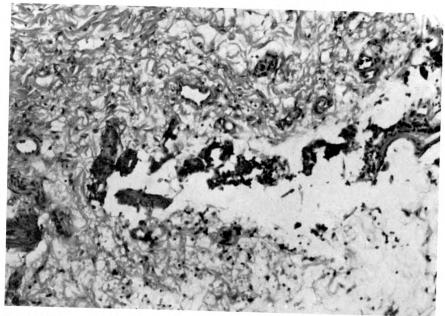


Fig. 5. Case i. High power microscopic view. Fused macrophages lie in the residuum of a collapsed pneumocyst in the gastric submucosa. (Hematoxylin, eosin and saffron.)

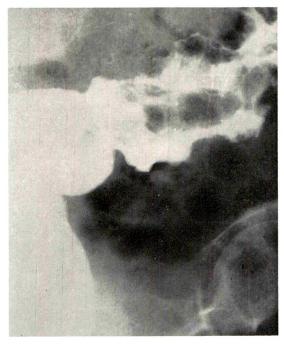
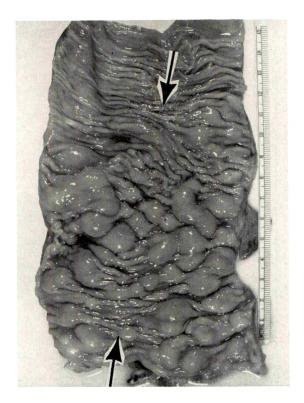


Fig. 7. Case II. Filling defects of the sigmoid segment from pneumatosis mimic multiple polyposis.



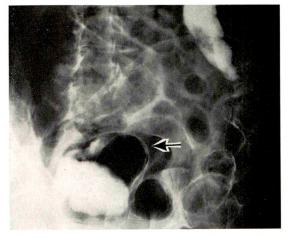


Fig. 8. Case II. Spindle shaped gas bubbles lie in the wall of a segment of the sigmoid loop (arrow).



Fig. 10. Case II. Longitudinal segment of the lower descending colon showing pneumatosis cystoides coli and isolation of the submucosal cysts.

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Fig. 9. Case II. So-called pneumatosis cystoides coli, submucosal in type. The polypoid protrusions are individual and lie in two axial bands in line with the bases of the appendices epiploicae, leaving an intervening gutter (arrows).

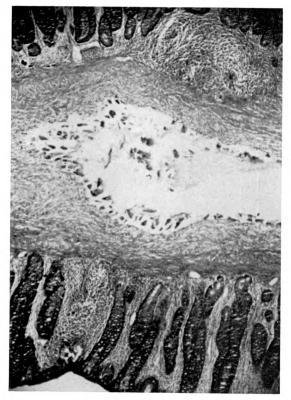


Fig. 11. Case II. Microscopic view of a polypoid colonic fold showing the enclosed pneumocyst. Fusion phagocytic giant cells are distributed over the wall, forming a pseudolymphatic lining. (Hematoxylin, eosin and saffron.)

fibrillation, who was admitted with paroxysmal nocturnal dyspnea. He complained of the recent passing of some blood by rectum. On sigmoidoscopy a nodular swelling of the mucosa was found at 16 cm. He died unexpectedly and at autopsy submucosal cystic pneumatosis of the sigmoid, descending and left transverse colon was found without mucosal ulceration. There was also a recent cerebellar infarction with swelling and formation of a medullary pressure cone. No abnormalities were noted in the chest. Microscopic examination showed adjacent intestinal pneumocysts of different ages, some without lining, but most with PAS positive syncytial phagocytes and giant cells forming a pseudolymphatic lining. Collapsed cysts showing mild fibroblastic repair and lymphocytic infiltration were seen between the more recent lesions (Fig. 14).

### DISCUSSION

Until recently the pathogenesis of "cystic pneumatosis" of the intestine was obscure.

Although authors of textbooks state that the condition is rare, there are more than 300 instances recorded in the literature.<sup>8</sup> Stiennon,<sup>14</sup> and Keyting and his colleagues,<sup>7</sup> who added greatly to our knowledge of the process, became interested when they encountered a number of personal cases at the same time. There is little doubt that the condition is common but seldom diagnosed, for the roentgenologic pathology is incompletely defined as teaching material.

When bacterial origin was unconfirmed, Masson<sup>10</sup> suggested that pure biochemical fermentation caused dilatation of the intestinal and mesenteric lymphatics—a "lymphopneumatosis." However, Tung and Ngai<sup>15</sup> failed to reproduce the intestinal pneumocysts experimentally by injection of air into submucosal lymphatics. The single layer of flattened, stretched cells, which Masson<sup>10</sup> noted lining the lumen of

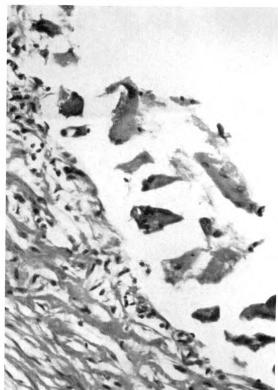


Fig. 12. Case II. High power microscopic view of a pneumocyst margin. Syncytial phagocytes, with occasional intracytoplasmic vacuoles and particles, are seen directly upon bare connective tissue.

cysts, is observed only when the process has been present for some time. These cells are not noted when the cysts have been recently formed.<sup>14</sup> We stained many sections of blocks from cysts of all our 3 cases. Bacteria were not found with Gram's stain. The periodic-acid-Schiff reaction, also combined with alcian blue stain, was next used with techniques known to be of value in the investigation of the possible mesothelial origin of cells in exudates. In all instances the flattened syncytial lining cells, together with the included multinucleated giant cells, were very strongly PAS positive. Multiple fine PAS positive granules were found with particular frequency in the perinuclear zones. This indicates their identity as phagocytes from tissues, which do line cavities as flattened forms or fuse to form multinucleated giant cells. It is worth noting that Wright<sup>16</sup> in 1930 reported similar giant cell reaction around gas filled

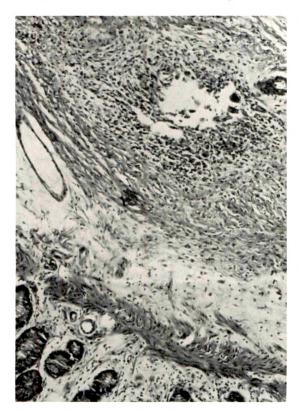


Fig. 13. Case II. An old healing pneumocyst is seen in the colonic submucosa deep to the muscularis. Fibroblasts, lymphocytes and fusion phagocytic giant cells form a reparative microgranuloma.

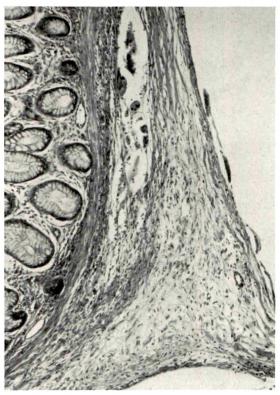


Fig. 14. Case III. Three pneumocysts in different stages are seen in the colonic submucosa. The most recent one shows a bare connective tissue wall, the largest has a parietal lining of flattened syncytial phagocytes, while the smallest shows collapsed, fusion phagocytic giant cells and fibroblastic repair.

spaces, occurring several days after the experimental injection of gas into subcutaneous tissues.

There are many reports of pneumatosis curiously affecting segmental portions of the small bowel, with very characteristic multiple skip areas. Some of these investigators felt that the duodenum, stomach and even the colon were not affected. However, it is now evident that all segments of the intestine may be involved. In an analytical review, Stiennon<sup>14</sup> showed that the bubbles must track by dissection radiating from the roots of the mesentery along the courses of the larger branches of the abdominal aorta. These tracks, later lined by flattened tissue phagocytes, become the "distended lymphatic channels" or fine linear scars noted by some authors.5 The gas penetrates with arteries to form isolated submucosal pockets, or perhaps to balloon the serosa. Unlike the vascular supply of the small intestine, colonic arteries do not enter at the mesocolic border, but divide there, then encircle the colon in its subserosa. Small branches are formed to the colonic wall at intervals, especially in the parallel rows of epiploic appendage bases, where they pierce the circular muscle coat to join the submucosal plexus. The linear arrangement of submucosal cysts corresponds with the appendices epiploicae insertions (Fig. 9). This feature has not been referred to so far as we are aware. It supports Stiennon's viewpoint.

Analyses4 of the gas from the cysts have shown a composition approximating atmospheric air. This had always been considered a diffusion effect of stagnation, explicable on the basis of differential rate of absorption of gases by the tissues. The connection between the facts that air persists in tissues much longer than carbon dioxide or oxygen and slow resorption of a massive pneumoperitoneum or cysts recorded in many articles has escaped notice. Very rapid development of abdominal swelling has been seen on many occasions. One instance is reported with recurrent pneumoperitoneum, or pneumatosis intestinalis without peritonitis, observed over 9 years.4 Clearly, it is an inflationary phenomenon.

A recent study of clinically associated conditions8 has shown that about 85 per cent of the patients with pneumatosis intestinalis cystoides have intestinal obstruction of one sort or another. The incidence of pyloric obstruction has ranged as high as 72 per cent. Such observations led to a search for transient breaches in intestinal mucosa which could cause segmental pneumatosis from intestinal gas penetrating into the mesentery. This has never been shown, even in such wide-spread conditions as chronic ulcerative colitis, and experimental reproduction has been a failure.14 The characteristic absence of peritonitis, even in the massive pneumoperitoneum, has led to abandonment of the theory of intestinal or gastric origin for the gas in the cysts.

In experimental investigations, following

an accidental production, Macklin<sup>9</sup> showed that pulmonary interstitial emphysema tracked along the main vessels to the mediastinum and in some cases through the diaphragm producing pneumatosis of the left side of the colon. Later, with equal significance, Ham and Leeson<sup>6</sup> showed that once air gained access to the pulmonary interstitial tissues, it could not escape back into the remainder of the lung, for it was confined inside dense fascial sheaths around pulmonary vessels. It is seldom appreciated that such a tension pneumomediastinum is extremely unlikely, for anatomic reasons, to decompress through the cervicothoracic inlet. On each side the inlet is partly closed by dense Sibson's fascia (fused suprapleural membrane), which forms a conical tent running from the inner border of the first rib to the transverse process of the seventh cervical vertebra. The pretracheal layer of deep cervical fascia fuses superiorly with hyoid bone and the laryngeal cartilages, and inferiorly it lies in front of the trachea to fuse with fibrous pericardium over the great vessels. Laterally, it fuses with dense fascia of the sternomastoid investment. Thus the "visceral compartment of the neck" is closed superiorly. The common carotid artery and jugular vein are sandwiched in a sheath formed by the pretracheal fascia anteriorly and prevertebral fascia posteriorly. Experimental rupture from tension pneumomediastinum requires considerable pressure before it will burst in a notably explosive and massive fashion.9

It is a common misconception that air can escape easily through this opening to produce a massive emphysema in the superficial fascia of the entire body, which is sometimes seen as a complication of chest injuries. This superficial "interstitial emphysema" of the entire subcutaneous layer occurs, apart from tracheal injury, most commonly when air is injected directly into the lamina of the superficial fascia, either deliberately, 6 or by inflation from the lung through an area of pleural adhesion and chest wall disruption.

Aiken and Smith, during observation of the normal function of these fascial planes during block dissections of the neck, noted a thoracic suction mechanism pulling air through the only communication of the thorax with this upper cervical fascial compartment. Air travelled down the jugulocarotid fascial sheaths during inspiration into the mediastinum. It did not escape back through the opening during expiration because the engorgement of jugular veins caused a ball valve action. Four of their cases developed fatal tension pneumomediastinum or pneumothorax from this one-way thoracic pump mechanism.

A notable advance in the knowledge of abdominal cystic pneumatosis has been made by Doub and Shea,3 who reported 16 patients, 15 of whom curiously had severe asthma. This attracted the attention of Keyting and his colleagues, who in I month observed 3 cases of cystic pneumatosis in patients with severe pulmonary disease. They showed that in dogs, air which was injected into the root of the left lung passed along the areolar tissues of the fascial planes around the aorta, through the diaphragm to produce pneumatosis over the left side of the colon. Further experiments on cadavers confirmed the supposition of Stiennon14 that air injected around the inferior mesenteric artery would produce pneumatosis at the same intestinal site. For these reasons Keyting et al.7 suggested that all instances of pneumatosis intestinalis were secondary to other diseases, whether from pulmonary alveolar rupture or intestinal mucosal erosion allowing a seepage of

Not all instances of pneumomediastinum (mediastinal emphysema) decompress in this way. Potter<sup>13</sup> records its occurrence "with some frequency" in infants, in some even with inversion of the diaphragm with resultant death as in Aiken and Smith's¹ adult cases. It is not known whether abdominal decompression occurs only through common minor congenital diaphragmatic defects. One wonders, knowing the inadequacy of the conventional autopsy examination of the chest, whether the unexplained sudden deaths which may follow blast injury, asthma, vomiting or coughing are

sometimes due to undetected tension pneumomediastinum which does not decompress.

A review of the clinical features of "pneumatosis" has shown so many associated primary conditions that some authors have realized that another factor, such as severe malnutrition, may be related in some way.<sup>4</sup> There appears to be little similarity in the cases reported; however, after a careful review of the literature, we have been impressed by the constant occurrence of vomiting, coughing, forcible regurgitation, straining or artificial inflation of the lungs. In every instance the diseases associated with pneumatosis are linked as prominent causes of these abrupt increases in intrathoracic pressure.

The massive vomiting in cases of pyloric stenosis is the best clinical example of all of these. Experimentally, Polak and Adams<sup>12</sup> showed that only 80 mm. pressure of mercury is necessary to produce pulmonary interstitial emphysema in dogs. Abrupt distention of delicate alveoli, especially when the surrounding pulmonary blood vessels are of low tension, has been shown experimentally by Macklin9 to provide a steady source of inflow of air into the interstitial lung tissues during the negative pressure of inspiration. In 1938 Botsford and Krakower<sup>2</sup> had reported 2 cases of intestinal pneumatosis in which a large air track was clearly demonstrated in the position of the cisterna chyli and thoracic duct. Air embolism did not occur and it seems likely that these were pseudolymphatics as in Masson's cases. Recently, Plachta and Speer11 showed a similar mechanism for the production of nonbacterial gastric emphysema in 3 cases due to a rupture of an emphysematous bulla of the lung into the periesophageal areolar tissue.

## ROENTGEN FINDINGS

So far as we are aware Figure 2 is the first roentgenogram on which a route of such air from the thorax in a case of abdominal pneumatosis has been demonstrated. The various types of deep interstitial emphysema become understandable and it ap-

pears that this is the pathogenesis of the curious, and usually harmless, abdominal visceral emphysema which is associated with so many diverse conditions. The various deep visceral fascial planes and compartments are also well demonstrated on these roentgenograms. Their characteristics depend very largely upon the final site of air which is forced out of the thorax through the para-aortic sheath erupting along the distribution of the celiac, superior or inferior mesenteric, and iliofemoral vessels.7 This has been illustrated in a number of excellent articles. The roentgen features, however, have not been gathered together to our best knowledge and are therefore presented. These are:

- 1. Paravertebral air in the mediastinum (Fig. 2).
- 2. An air strip outlining the stomach, probably subserosal, in a double ring contour. This was clearly shown by Druckman *et al.*<sup>4</sup> Air may also outline the course of the celiac artery branches as in Figure 3.
- 3. Multiple grape-like bubbles of translucency mixed with small bowel gas shadows, and perhaps with hepatic interposition. The air may be radially distributed in the mesentery as shown by Keyting *et al.*<sup>7</sup>
- 4. A colonic double ring-within-a-ring contour, or linear pneumatosis in the lateral view, which indicates subserosal emphysema. Submucosal bullae produce multiple filling defects imitating coarse polyposis as shown by Kushlan.<sup>8</sup> Unlike polyposis, it is often segmental.
- 5. Air in the lateral abdominal walls which is less common follows lateral branches of the aorta, such as the renal arteries.
- 6. Air infiltrating finally the inguinal canals tracking along iliofemoral arterial fascial sheaths.<sup>14</sup>
- 7. Silent pneumoperitoneum, often massive, and typically without peritonitis, is extremely characteristic. Serosal pneumocysts float to the superior surface of the displaced intestine and their very fine walls may be seen on careful examination (Fig. 4).

## SUMMARY

So-called pneumatosis cystoides intestinalis is the decompression of a silent tension pneumomediastinum from painless alveolar rupture. The visceral compartment of the deep cervical fascia is closed. Suction and pulsion in the thorax inflate sheaths around pulmonary arteries, which are continuous with the fascial sheath of the aorta, and air is propelled in the segmental distribution of its main branches throughout the abdomen.

The pneumocysts become lined by a syncytium of tissue phagocytes forming pseudolymphatic spaces. Special stain studies in our 3 cases appear to substantiate this; in one, silent pneumomediastinum, widespread pneumocystosis intestinalis, and massive pneumoperitoneum without peritonitis were also detectable roentgenographically. Such pneumatosis is usually a recurrent process. Roentgenograms demonstrate it in the various deep visceral fascial planes and their compartments.

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# THE EFFECTS OF INTRA-ARTERIAL INJECTION OF CONTRAST MEDIA ON CANINE INTESTINE\*

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KNOWLEDGE of the local and systemic effects of different contrast media upon the body is required for the successful application of roentgenologic vascular contrast studies. Our previous experiences<sup>4</sup> showed that tissue damage could be produced with relatively small amounts of some media while other contrast materials were less nocuous.

describes the histologic This study changes occurring in segments of the small intestine of the dog following injections of radiopaque contrast media into the isolated mesenteric artery of different intestinal segments. It compares the effects of several frequently used iodine-containing vascular contrast media in approximately the same concentration. The media investigated were: Miokon (sodium diprotrizoate), Hypaque (diatrizoate sodium), Renografin (methylglucamine diatrizoate), Ditriokon (sodium diprotrizoate and diatrizoate), Sodium-Conray (sodium iothalamate), and Methylglucamine-Conray (methylglucamine iothalamate). The concentration of each contrast medium was adjusted so that its iodine content roughly approximated that of either 50 per cent or 25 per cent Hypaque.

## METHOD AND RESULTS

Adult male mongrel dogs weighing approximately 30 pounds were anesthetized, by injecting sodium pentabarbital intravenously, and celiotomy was performed. A 21 gauge scalp vein needle was placed in the lumen of a mesenteric artery supplying a loop of distal ileum. Great care was taken not to injure the adjacent veins. The contrast medium selected was injected manually and roentgenograms were made at the

completion of the injection. Many injections of contrast medium were followed by an injection of 20 ml. of saline in order to flush the contrast medium out of the vessels. When several loops of intestine were injected in the same dog, one intermediate artery and vein were left intact. Twentyfour intestinal segments were used as controls; the artery was ligated only and nothing injected in 12, and 8 ml. of saline only was injected intra-arterially in 12. All intestinal segments were studied grossly and microscopically after resection or autopsy, and the microscopic changes were graded. Resections were performed 3 to 5 weeks following the injections of the contrast material in all surviving dogs. The tissue sections stained with hematoxylin and eosin were studied without knowledge of the contrast medium that was injected, if any. Tissue changes were graded from o to 3. Grade o represented histologically normal tissue; Grade I was reserved for tissue showing slight perivascular infiltration of inflammatory cells and degenerative changes of minor degree in the muscle and mucosa (Fig. 1). Grade 2 was assigned to sections showing marked perivascular inflammatory infiltration and severe muscular degeneration or necrosis (Fig. 2). Grade 3 was reserved for sections of bowel that showed perforation in addition to the degenerative changes described above (Fig.

The results are summarized in Table 1. Flushing out the contrast material with 20 ml. of saline did not prevent damage to the intestine or change the results.

### CONCLUSIONS

The method of assay of the toxicity of

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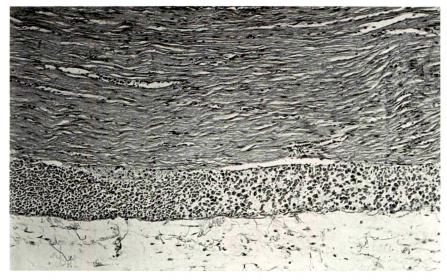


Fig. 1. Grade 1 changes: Degeneration of outer muscular layer along mesenteric attachment of canine ileum. H&E×140(W.U. Ill. #62-3557).

different contrast media used in this study proved effective. The histology of resected intestinal segments of dogs was studied after the intra-arterial injection of Miokon, Hypaque, Ditriokon, Renografin, and the Sodium and Methylglucamine salts of Conray. Renografin and Methylglucamine-Conray proved to be less damaging to the intestine of dogs than the other media. It should be noted that the dogs that survived the injections did not appear ill in spite of the fact that some had significant histologic changes in their intestine.

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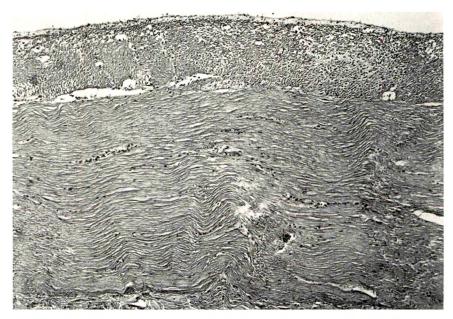


Fig. 2. Grade 2 changes: Necrosis of entire muscular coat of canine ileum. H&E×130(W.U. Ill. #62-3558).

TABLE I

Amount and Concentration Injected	No. of Intestinal Segments Injected	No. of Segments and the Grade of Tissue Injury (o through 3)			
		*0	I	2	3
Miokon					
8 ml. 50%	6	3	I	0	2
4 ml. 50%	4	2	I	I	0
2 ml. 50%	2	0	2	0	0
4 ml. 25%	3	I	2	0	0
2 ml. 25%	3	I	2	0	0
Totals	18	7	8	I	2
Нурадие					
16 ml. 50%	3	2	I	0	0
8 ml. 50%	4	I	3	0	0
4 ml. 50%	5	4	I	0	0
2 ml. 50%	4	4	0	0	0
4 ml. 25%	4	4	0	0	0
Totals	20	15	5	0	0
Renografin					
16 ml. 60%	2	2	0	0	0
8 ml. 60%	2	2	0	0	0
4 ml. 60%	2	2	0	0	0
2 ml. 60%	2	2	0	0	0
4 ml. 30%	2	2	0	0	0
2 ml. 30%	2	2	0	0	0
Totals	1.2	12	0	0	0
Ditriokon					
8 ml., approxi-					
mately 50%	6	4	2	0	0
8 ml., approxi-					
mately 25%	6	6	0	0	0
Totals	1 2	IO	2	0	0
Sodium-Conray					
8 ml. 50%	8	5	2	I	0
8 ml. 25%	8	6	2	0	0
Totals	16	ΙΙ	4	I	0
Methylglucamine-C	onray				
8 ml. 50%	8	8	0	0	0
8 ml. 25%	8	8	0	0	0
Totals	16	16	0	0	0
Controls	24	24	0	0	0

 $<sup>^*</sup>$  o=No significant changes. 1=Perivascular infiltrates and minor degenerative changes. 2=Same as 1, but more severe; also necrosis. 3=Same as 2, with perforation.

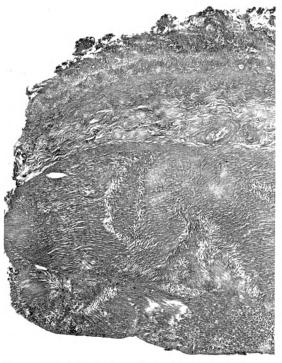


Fig. 3. Grade 3 changes: Necrosis of entire muscular coat of canine ileum with perforation. H&E×90 (W.U. Ill. #62–3559).

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## SMALL BOWEL OBSTRUCTION VERSUS ADYNAMIC ILEUS\*

## A STUDY USING A WATER SOLUBLE ORAL CONTRAST MATERIAL†

By BERNARD J. OSTRUM, M.D., and E. RALPH HEINZ, M.D. PHILADELPHIA, PENNSYLVANIA

EVALUATION of the patient with pain and acute abdominal distention may be very difficult when the radiologist is limited to plain roentgenograms. Barium has been employed to study these patients, particularly in Europe where Frimann-Dahl<sup>5</sup> has given an excellent analysis of this method. However, the use of barium in the acutely ill patient has never become popular in this country. Radiologists dislike the flocculation which frequently occurs even with micro-barium. Surgeons object to the slow transit time which may delay definitive surgery and to the possibility that barium may enter the peritoneal cavity and cause complications. When water soluble contrast material<sup>1-4,6,7,9,11</sup> became available, we decided to use this material in studying a large number of patients who presented themselves at a city hospital with severe acute abdominal distention.10

## MATERIALS AND METHODS

Hypaque powder (sodium diatrizoate)<sup>2</sup> is prepared as a water soluble iodinated compound which is miscible with water, blood and succus entericus. Absorption from the gastrointestinal tract is minimal, and when absorbed is excreted by the kidneys. Passage into the peritoneal cavity is without incident or complication. At surgery it is impossible to distinguish from intestinal contents and can be readily aspirated through the suction tube. It has high tonicity and this contributes to its rapid transit time through the gastrointestinal tract, and the mild diarrhea which occasionally accompanies its use. It is diluted in the small bowel by the succus entericus and,

therefore, is less radiopaque in the jejunum and ileum. As water is absorbed in the right colon, the contrast becomes very dense and is readily recognized on the roentgenogram. It does have a bitter taste which may be masked by cherry syrup or vanilla extract, but since it is usually used after intubation this is no problem.

Fifty grams of diatrizoate sodium dissolved in 120 cc. of water are given. Administration is usually through an indwelling tube. Suction on the tube is discontinued for at least I to 2 hours and preferably as long as the surgeon will permit. Usually roentgenograms are taken at 30 to 60 minute intervals. If the contrast medium is introduced through a long tube into the jejunum, roentgenograms must be made at no less than 15 minute intervals, as transit may be complete in as little as 45 minutes in the normal patient. When introduced into the stomach, the patient must be positioned so that the contrast material will leave the stomach properly. This usually means positioning the patient on his right side for 30 minutes. Fluoroscopy is not performed.

## RESULTS

One hundred cases of possible small bowel obstruction were studied. The transit time from stomach to cecum is 30 to 90 minutes in the normal patient. In adynamic ileus, contrast material will pass to the cecum within 3 hours with rare exception (Fig. 1, A and B). Occasionally, it may require up to 6 hours.

Partial small bowel obstruction will require 3 to 48 hours or more for the contrast

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<sup>†</sup> Hypaque sodium powder. Hypaque liquid also available as a 40 per cent solution in 120 ml. volume by Winthrop Laboratories, New York, New York.

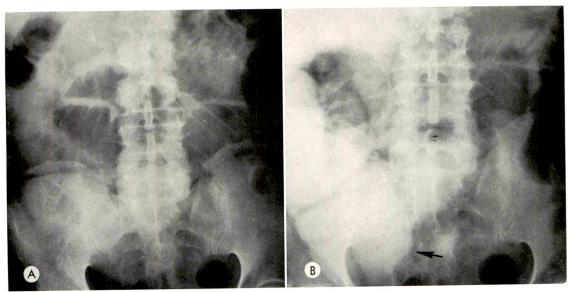


Fig. 1. Adynamic ileus. A 69 year old man developed distention, pain and hypoactive bowel sounds 9 days postoperatively (suprapubic prostatectomy). (A) Survey roentgenogram shows distention mainly of the small bowel loops. (B) Hypaque passed to the cecum in 2 hours (arrow). The above roentgenogram was taken at 6 hours. A diagnosis of adynamic ileus was made. Tube decompression was effective in 36 hours.

B, and A, B and A. In severe to comunities removed by suction or vomiting; plete obstruction, the contrast material will however, the danger of inspissation is

medium to pass to the cecum (Fig. 2, A and remain in the small intestine up to 5 days

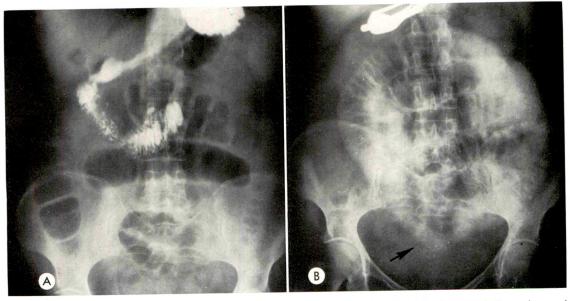
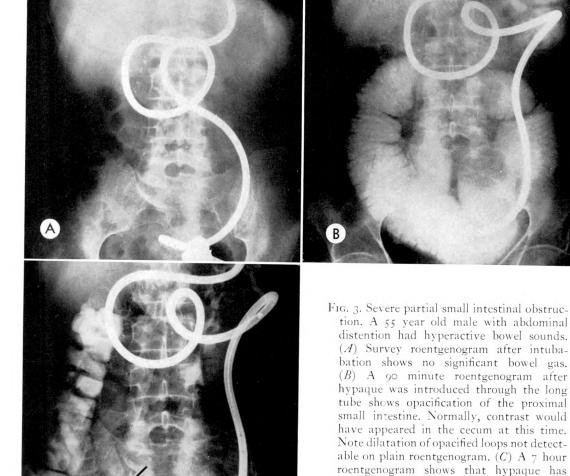


Fig. 2. Moderate partial small intestinal obstruction. A 55 year old female with abdominal distention and vomiting had hypoactive bowel sounds. (A) Five minute roentgenogram shows considerable colon gas as well as dilated small bowel loops. A small amount of biliary air is present in the right upper quadrant. (B) Ten hours after hypaque was given, there is no contrast in the cecum and the small intestine is almost completely opacified. Mild dilatation is present. At operation a large gallstone was found which had obstructed the terminal ileum (arrow).



avoided with the water soluble radiopaque solution in contrast to a barium suspension. There is always a sharp end point when the contrast material reaches the cecum as the diluting fluid is absorbed and it is much more concentrated than in the small intestine. When a mass lesion is present, whether neoplastic or inflammatory, small bowel displacement may occur. The column may be seen to terminate at this point (Fig. 4, A and B).

In mesenteric occlusion, which clinically may present as an adynamic ileus, the column terminated at the site of gangrenous bowel in the 2 cases studied (Fig. 5, A and B).

was found.

reached the cecum, and there is marked dilatation of the ileum faintly outlined by contrast (arrows). Note "stretching" of valvulae conniventes. At operation a carcinoma of the ileum with severe obstruction

## DISCUSSION

Barium is the contrast medium of choice in chronic partial small bowel obstruction where large quantities of succus entericus are not present. However, it has a number

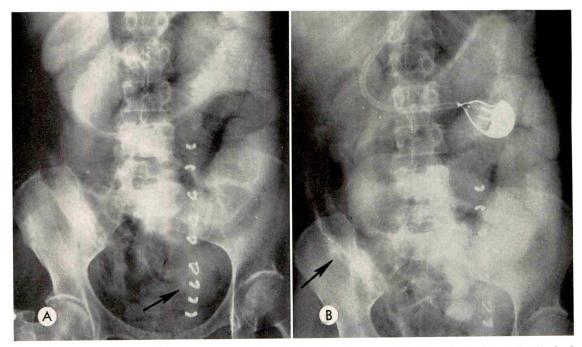


Fig. 4. Severe small intestinal obstruction. A 67 year old female with abdominal distention and pain had decreased bowel sounds 4 days following a hysterectomy. The clinical diagnosis was adynamic ileus. (A) Hypaque showed moderate dilatation of the small intestine to a point of obstruction in the left lower quadrant at 8 hours (arrow). (B) At 19 hours note the same opacification of the dilated small intestine proximal to the obstruction, but now a thin dense column of contrast may be seen in decompressed bowel in the right lower quadrant (arrow). At operation a small pelvic abscess was found in the left lower quadrant obstructing the small intestine.

of disadvantages in severe acute partial small bowel obstruction. It frequently flocculates when large quantities of fluid are present. It has a long and variable transit time. If the bowel is compromised as it is with mesenteric occlusion or strangulation obstruction, <sup>12</sup> barium may pass into the peritoneal cavity. If a large bowel obstruction has not been excluded, conversion of a partial bowel obstruction to a complete obstruction is possible. As a result of these objections, frequently no contrast agent is given and much valuable information is lost.

Water soluble contrast material may be given during the patient's most acute phase. As it is water soluble, it does not flocculate. If it should pass into the peritoneal cavity, it would be absorbed promptly without residual effect. It will not cause large bowel obstruction. Because it is hypertonic, it has a rapid and relatively fixed transit time. Since it will pass

promptly through the small intestine in adynamic ileus<sup>8</sup> and will be delayed in small bowel obstruction, it provides an excellent functional method for evaluating acute abdominal distention. After one has experience with the method, partial obstruction may, by use of a water soluble radiopaque material, be diagnostically divided into mild, moderate and severe. Since in many of the mild and moderate obstructions tube decompression may be completely effective, surgery may be avoided in many patients. This is particularly helpful in the postoperative patient where reoperation is very undesirable.

## SUMMARY

One hundred cases of suspected acute intestinal obstruction have been studied with water soluble contrast material. The normal transit time from stomach to cecum is relatively fixed at 30 to 90 minutes. Water is absorbed in the right colon so that the

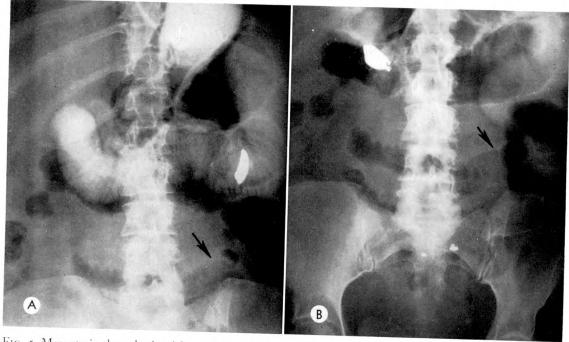


Fig. 5. Mesenteric thrombosis with small intestinal obstruction. A 45 year old female with distention and abdominal pain had decreased bowel sounds. (A) Contrast is seen proximal to an isolated small bowel loop over L-4 vertebral body (arrow). Note separation of this loop from the others on the 3 hour roent-genogram. (B) At 6 hours, hypaque terminates at the isolated loop (arrow). As a result of the contrast examination, surgery was performed. Six feet of gangrenous bowel was found at this site. Presumably the propulsive activity present in adynamic ileus is lost when local tissue compromise occurs.

contrast becomes very dense, which gives a sharp end point. In adynamic ileus, contrary to popular opinion, the contrast medium has a normal or only slightly prolonged transit time. This usually requires 3 hours or less, but may occasionally take up to 6 hours.

In partial small intestinal obstruction the transit time ranges from 3 to 48 hours or more. The degree of obstruction is proportional to the delay in transit time. Because the normal transit time is very short and relatively fixed, small increases in absolute time represent significant percentage delay in transit. Water soluble contrast material opacifies the small bowel sufficiently to permit observations on the caliber of the bowel, even when the loops are filled with fluid.

In mesenteric occlusion, which usually presents clinically as an adynamic ileus, the contrast terminated at the compromised segment in several cases.

Water soluble contrast material has its greatest value in the patient with acute and severe abdominal distention, where it provides an excellent functional evaluation of the small intestine despite the presence of large quantities of intestinal fluid. Barium under these circumstances is not an ideal contrast material. It is these acute cases, in which a management decision is most difficult, that water soluble contrast medium finds its greatest usefulness.

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# STUDIES OF THE COLON AND SMALL INTESTINES WITH WATER SOLUBLE IODINATED CONTRAST MEDIA\*

By WILLIAM H. SHEHADI, M.D. PORT CHESTER, NEW YORK

THE place of water soluble contrast media in the examination of the upper gastrointestinal tract has been well established and their use for this purpose has been widely accepted. Encouraged by the results of our initial observations when evaluating orally administered water soluble iodinated contrast media<sup>4,5,6</sup> in the examination of the upper gastrointestinal tract, we proceeded to evaluate their use in the examination of the colon and small intestines.

The purpose of this presentation is to report our experience in the studies of the small and large intestines with water soluble iodinated contrast media, particularly as a possible replacement for barium sulfate.

## EXAMINATION OF THE COLON

A series of 200 patients were examined (Table I), which included nonselected cases from our daily case load, referred for routine barium enema studies of the colon, as well as patients on whom routine barium enema studies were unsuccessful or considered not feasible.

## PREPARATION OF THE PATIENT

When indicated, the preparation of the patient was the same as that used routinely for barium enema examination, namely 2 ounces of castor oil administered at bed time and a cleansing enema the following morning immediately before the examination. The contraindications to the use of castor oil in the preparation of the patient for roentgenologic examinations should be observed. This cathartic should be omitted when it is clinically indicated to do so, in which case only cleansing enemas should be used.

## SAFETY OF THE CONTRAST AGENT USED

We have been impressed by the complete safety of the water soluble iodinated contrast media in a series of over 1,500 patients in whom hypaque oral, gastrografin and gastrografin "improved" by mouth, as well as hypaque enema by rectum were used. There has not been a single manifestation of intolerance or of any toxic reaction to these contrast media by any of the patients we examined. Renal excretion was observed only in 2 patients with small intestinal obstruction, one partial and the other complete. One might postulate that the prolonged stasis in the intestines, with delayed elimination through the normal channels and an abnormal state of the intestinal mucosa resulted in sufficient absorption through the intestinal mucosa to produce roentgenologic evidence of renal excretion.

## METHOD OF STUDY

The colon was examined by means of rectal enema using: 40 per cent hypaque solution; 40 per cent hypaque solution plus lavema; and 25 per cent hypaque solution with an equal volume of barium sulfate suspension. For oral administration, 40 per cent hypaque solution or gastro-

Table I

COLON STUDY WITH WATER SOLUBLE IODINATED

CONTRAST MEDIA IN 200 PATIENTS

No demonstrable pathologic findings	108
Colitis	7
Carcinoma	35
Volvulus	3
Intussusception	2
Diverticulitis	31
Pelvic tumor compressing or invading the colon	11
Obstruction—cause unknown	
	200

<sup>\*</sup> Presented at the Tenth International Congress of Radiology, Montreal, Quebec, Canada, August 25-September 1, 1962.

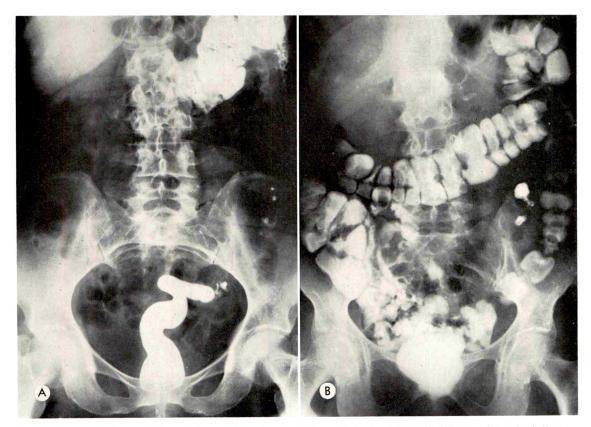


Fig. 1. Case No. A255. Eighty year old white female with a chief complaint of left lower abdominal discomfort. (A) Barium enema study shows only a small amount of barium irregularly outlining the distal colon. The patient was unable to retain the enema. Some diverticula are seen at the lower descending and sigmoid, but the over-all appearance and status of the entire colon cannot be determined. (B) Oral hypaque 40 per cent was administered, and 4 hours later the entire colon was well visualized. Note the normal caliber, contour, and haustral markings. The terminal ileum is well visualized. A small amount of the contrast material is still in the distal ileum.

grafin (more recently gastrografin improved) was used. This was followed by serial roentgenograms until the colon was completely outlined with the contrast agent.

Enema with 40 per cent hypaque. This resulted in excellent visualization of the colon with normal reflux into the terminal ileum. The caliber, contour and haustral markings of the colon were well brought out, the density of the shadows was equal, if not superior, to that obtained by a barium sulfate enema. At body temperature the enema was well tolerated by the patient. No cramps or irritation were experienced at any time. However, attempts at evacuation were not entirely successful and a satisfactory mucosal study could not

be obtained. As a result double contrast studies with air could not be performed. Often what appears to be complete obstruction when barium is used proves to be only partial obstruction when iodinated water soluble media are used, thus affording a good opportunity to localize and delineate the lesion causing the obstruction (Fig. 2, A-C; 4, A and B; 5; and 6, A-D).

Enema with 40 per cent hypaque plus lavema. In a preliminary study with lavema,\* which we made several years ago, it was found that the addition of a small amount of lavema powder (0.01–0.02 gm. per quart) to our routine barium sulfate

<sup>\*</sup>Lavema, brand of oxyphenisatin (3, 3-bis (4-hydroxyphenyl) oxindole) is supplied in small packages containing 0.02 gm. Lavema and Lactose q.s. ad 3.00 gm.

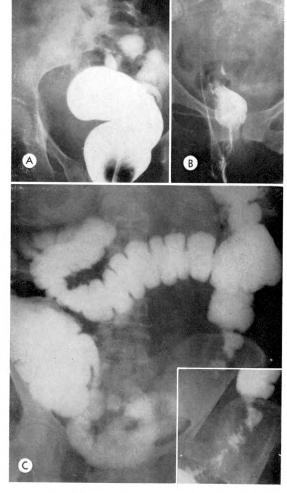


Fig. 2. Case No. A4156. Seventy year old white female with chief complaints of crampy pain in the right lower abdominal quadrant and localized tenderness over the course of the lower descending and pelvic colon. (A and B) Complete blockage of the barium is noted in mid-sigmoid (pre and post evacuation roentgenograms). (C and Insert) Hypaque enema 40 per cent delineates the entire colon and demonstrates the area of narrowing and irregularity, which is due to diverticulitis. Note the excellent filling of the colon, well defined haustral markings, diverticula at various levels of the colon, and the incompletely filled diverticula at the lower descending and sigmoid colon.

enema resulted in a more complete evacuation of the colon, due to the irritating effect of this compound on the colon mucosa. Based on these observations, we added lavema to the hypaque enema. Emptying of the colon was far better when lavema was used, but was not as complete as when barium alone was used.

Enema with 25 per cent hypaque plus equal volume of barium sulfate suspension. This combination has the advantages of both contrast media and results in excellent density. The barium remains in a state of suspension with no evidence of precipitation or separation from the hypaque solution. Emptying of the colon is appreciably improved when compared with the use of hypaque solution alone, but still not usually sufficient for a satisfactory mucosal study.

From a practical point of view, there did not seem to be any advantage to this combination.

Oral administration of hypaque or gastrografin. In the absence of small intestinal obstruction, the oral administration of 6 to 8 ounces of 40 per cent hypaque or gastrografin resulted in visualization of the colon, usually in its entirety, within 4 hours. This was noted during our initial studies of the upper gastrointestinal tract with water soluble iodinated contrast media.4,5 The colon may be studied following oral administration of hypaque as part of routine examination of the upper gastrointestinal tract (Fig. 7, A–C) or as a supplement to an unsuccessful and unsatisfactory barium enema examination (Fig. 1, A and B). This method is of value when there is partial or complete blockage in the colon to the flow of barium (Fig. 8, A and B; 9, A–C; and 10, A-C), or when the patient is unable to cooperate and retain the enema, as occurs often with elderly or very sick pa-

Fig. 4. Case No. A9825. Seventy-two year old white female with chief complaints of increasing constipation and increasing distention of the abdomen. (A and Insert) A barium enema study shows complete obstruction at about the mid-sigmoid. (B) On re-examination with 40 per cent hypaque, the enema passed through the site of obstruction, demonstrating incompletely filled diverticula and an area of narrowing in the sigmoid colon. The diverticula are noted at the level of the descending colon.

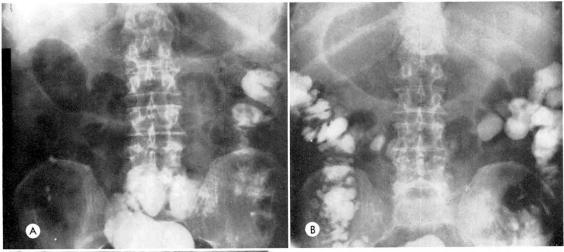
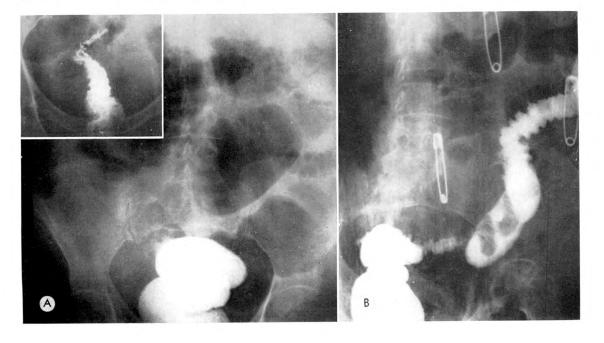




Fig. 3. Case No. A9673. Sixty-five year old male with a chief complaint of bleeding by rectum. (A) Attempts at administration of barium enema were unsuccessful. (B and C) After 40 per cent hypaque was administered by mouth, the colon was adequately delineated. Note multiple diverticula at various levels. Roentgenograms were made at 4 and 5 hours respectively.



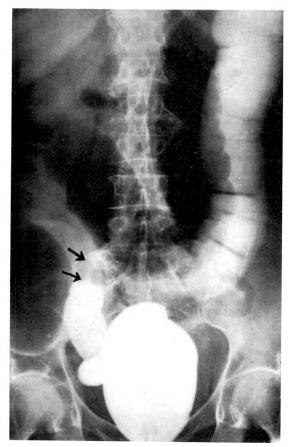


Fig. 5. Case No. A1808. Seventy year old white female with a chief complaint of progressive constipation of 6 months' duration. Rapidly developing abdominal distention was present during the preceding 3 days. A barium enema study demonstrated complete obstruction at about the midsigmoid with no indication as to the cause or exact site of obstruction; however, the hypaque enema study shows filling of the rectum and distal sigmoid, demonstrating incomplete obstruction at about the mid-sigmoid colon. Note the napkin ring deformity. The caliber is reduced to 8 mm. in diameter through a segment approximately 3 cm. in length. The colon is dilated proximal to the site of the lesion. The roentgenologic diagnosis of annular carcinoma of the mid-sigmoid was confirmed at operation.

tients (Fig. 1, A and B; and 3, A-C).

Often when on a barium study only a portion of the lower colon is visualized, the oral administration of hypaque or gastrografin will result in adequate delineation of the colon, demonstrating its position, outline, and the extent of patency

(Fig. 1, A and B). The contrast agent will stop at the proximal margin of an obstructing lesion, be this inflammatory or neoplastic. In the case of carcinoma, where the distal border of the obstructing lesion has been identified or where the lower shelf has been delineated by the enema, the orally administrated contrast agent will outline and define the proximal shelf of the tumor (Fig. 8, A and B; 9, A–C; and 10, A-C). Thus, the size, length and location can be demonstrated. Likewise, the status of the colon above the obstructing lesion can be determined. This is of importance to the surgeon in determining the type of operation to be performed. The possible presence of multiple lesions, a rare but nonetheless significant occurrence, can be satisfactorily determined or ruled out. In the case of obstruction due to inflammatory process, especially diverticulitis, the presence of a carcinoma can be ruled out by the appearance of the colon proximal to and at the site of obstruction. A complete obstruction to the enema flow may prove to be only partial to orally administered water soluble contrast medium (Fig. 8, A and B; 9, A–C; and 10, A–C). Thus the mucosa through the area of obstruction may be adequately visualized, the lumen of the colon delineated and the presence of diverticula often demonstrated. In any event there is no danger of a partial obstruction being misdiagnosed as a complete obstruction as would be the case if barium sulfate was used.

Not infrequently, when examining very sick patients, particularly elderly people who are unable to cooperate, repeated attempts at administration of barium enema, at most, result only in the pelvic or distal colon being filled. With orally administered water soluble contrast medium as a supplement, the colon may be outlined and an adequate survey of its status, caliber, position and contour may be made. Obstruction may be ruled out, the presence of gross lesions determined and diverticula, when present, may be visualized (Fig. 1, A and B; and 3, A–C).

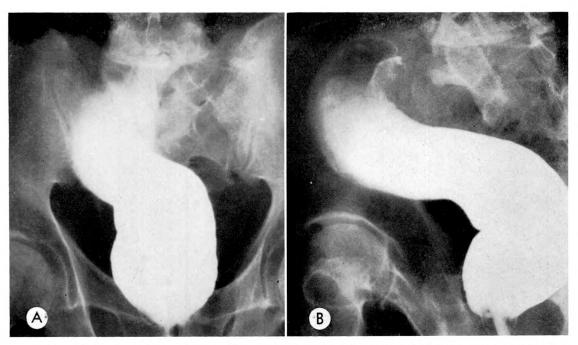


Fig. 6. Case No. A5719. Sixty-one year old white male with a chief complaint of increasing constipation. (A and B) Barium enema studies revealed complete obstruction to the flow of barium at the mid-sigmoid.

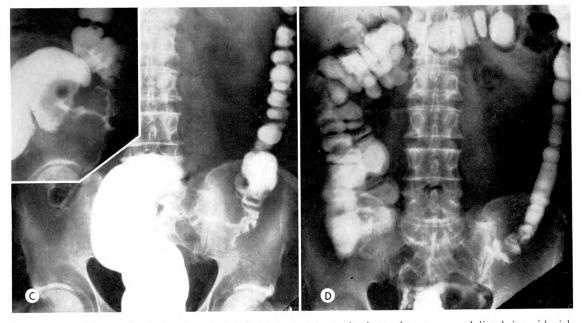


Fig. 6. (C and Insert) Immediate 40 per cent hypaque enema study shows the rectum and distal sigmoid with incomplete obstruction at the proximal sigmoid. Note the napkin ring deformity with an annular infiltrating lesion involving a 9 cm. segment of the colon. The caliber is reduced to approximately 0.3 to 0.4 cm. in diameter. (D) The remaining colon is well outlined. The diagnosis of carcinoma was confirmed at operation.



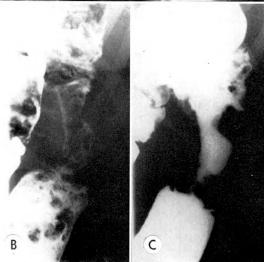


Fig. 7. Case No. A5638. Fifty-two year old white female with chief complaints of loss of weight and anemia. A gastrointestinal series was performed as part of a routine checkup, using gastrografin "improved." (A) At 4 hours a well defined defect is seen in the proximal descending colon, representing a napkin ring deformity. The caliber of the colon is reduced to 1 to 1.5 cm. through an 8 cm. segment. A diagnosis of annular carcinoma of the proximal

Roentgenograms are made as early as 3 hours after administration of the medium, and at hourly intervals thereafter, if necessary, until the oral contrast agent has cleared the small intestines and the entire colon is outlined. Usually, a roentgenogram at 3 or 4 hours is adequate. Rarely is it necessary to obtain roentgenograms beyond this time.

This procedure should not be used as an excuse for poor technique in examinations of the colon nor is it intended as a replacement for properly executed studies.

# EXAMINATION OF THE SMALL INTESTINE

Examination of the small intestine is still not entirely satisfactory. The contrast material becomes increasingly diluted as it travels through the small intestine with resultant corresponding decrease in the density of its shadow. The progress of the contrast material, however, permits a rapid survey of the caliber and contour of the small intestine. With the present method of examination, detail of the mucosal pattern is not as clearly defined as when barium alone is used. However, space occupying lesions can be recognized and the site of obstruction, whether partial or complete. can be accurately determined. At times, the nature of the lesion can be identified. The contrast material may be given by mouth or introduced through a Miller-Abbott tube, after its tip has reached the site of obstruction. The use of a Miller-Abbott tube calls for a smaller quantity of the contrast agent. We use 40 per cent hypaque oral or gastrografin improved which has a tween content about 4 times that of regular gastrografin. While these have proven to be superior to other media used in the study of the esophagus, stomach and duodenum, no special advantage

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descending colon was made from this study. (B and C) Barium enema studies confirm the diagnosis which was subsequently proved at surgery,

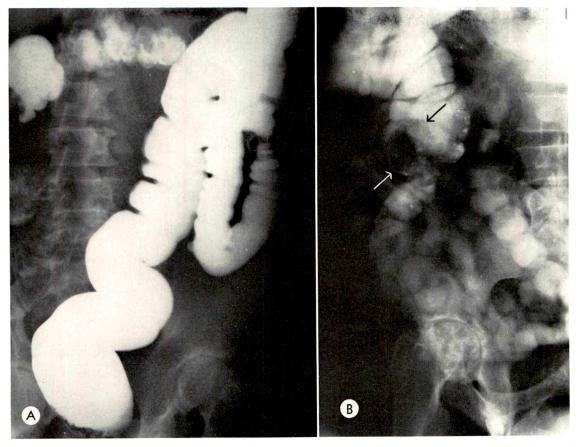


Fig. 8. Case No. A5327. Fifty-one year old white male with chief complaints of gastrointestinal bleeding and anemia. (A) Barium enema study shows barium from the rectum to the proximal transverse colon with complete blockage. There is an irregular contour suggesting the distal border of a tumor. The examination was supplemented by orally administered hypaque 40 per cent. (B) At 4 hours the proximal colon is well visualized. A well defined fungating more or less polypoid lesion is demonstrated, which is approximately 5 cm. in diameter, in the mid-ascending colon. The roentgenologic diagnosis of polypoid tumor—adenocarcinoma of the ascending colon—was confirmed at operation.

in studies of the small intestine have been noted.

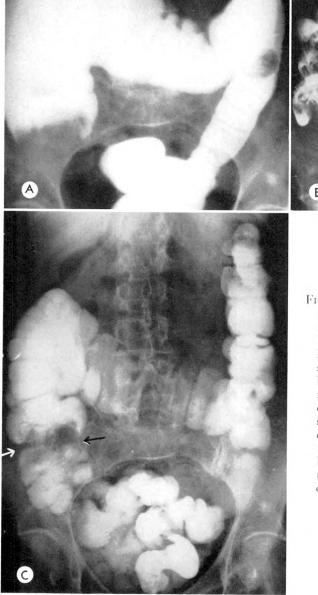
Because of its dilution in the small intestine, with resultant inadequate delineation of mucosal detail, we tried a mixture of water soluble iodinated contrast agents, hypaque 25 per cent or gastrografin, with an equal volume of barium sulfate suspension (Fig. 11, A-C). Studies of the esophagus, stomach and duodenum were excellent, but as the contrast material passed into the jejunum the barium and hypaque or gastrografin separated as each traveled at its normal rate. At I hour the barium was still in the jejunum, where it normally would be, while the water soluble contrast

medium outlined the distal ileum and proximal colon. Successive roentgenograms showed the separate progress of the barium and the hypaque or gastrografin.

This method of examination has proved so far to be of limited value in the study of the small intestine.

# INDICATIONS

The use of rectally administered water soluble iodinated contrast media in the examination of the colon is indicated (1) in patients clinically suspected of having obstruction of the colon; (2) in all patients in whom complete obstruction has been demonstrated on a barium enema study.



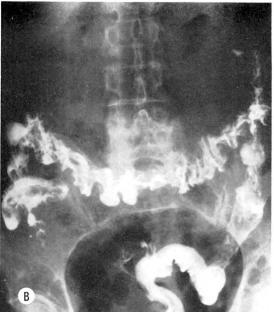


Fig. 9. Case No. 14213. Seventy-four year old female with a chief complaint of a mass in the right lower abdominal quadrant. The bowel habits were normal and there was no loss of weight. (A and B) Barium enema studies show the colon filled up to the distal border of the tumor. (C) Following oral administration of hypaque, the base of the cecum is well filled and the entire tumor is sharply outlined, both at its proximal and distal end. The lumen is reduced to about 1 cm. in diameter through a 2 cm. segment by an annular infiltrating lesion. The diagnosis of annular carcinoma was confirmed at operation.

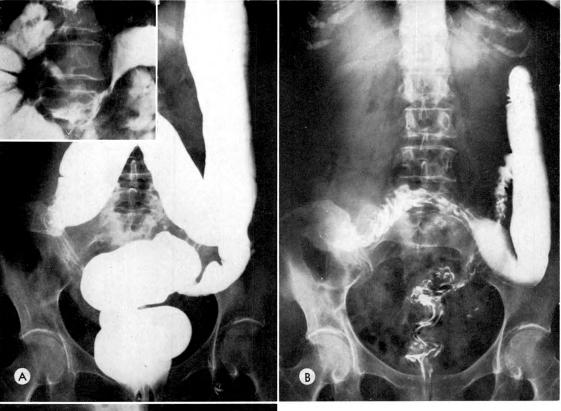
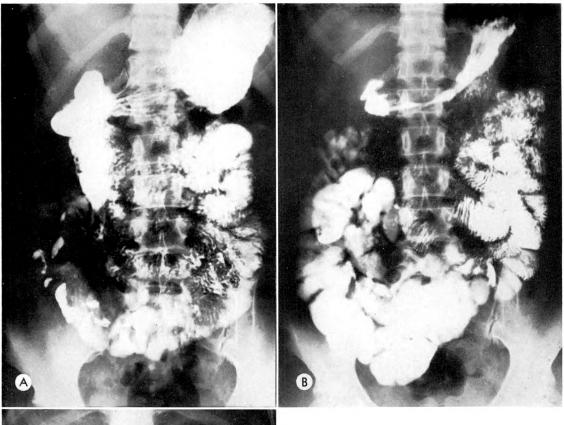




Fig. 10. Case No. A13684. Seventy year old female with a chief complaint of a palpable right upper abdominal mass, clinically diagnosed as tumor of the ascending colon. (A and B) Barium enema study shows the colon from the rectum to what seems to be the region of the hepatic flexure where complete obstruction is encountered. (C and Insert of A) Hypaque 40 per cent solution was given by mouth and 4 hours later the cecum, ascending colon, hepatic flexure and proximal transverse were well outlined. The cecum is low in position, practically at the bony pelvis. A small amount of contrast material is seen through the tumor mass with a maximum width of 0.8 to 1 cm. and a length of approximately 8 cm. This corresponds to the clinically palpable mass. Note tumor shelf at either side. The hypaque studies showed the location of the tumor to be in the proximal transverse colon and not in the ascending colon, as clinically suspected. The position and appearance of the colon proximal to the lesion are well demonstrated and both sides of the tumor are now well outlined. The roentgenologic diagnosis of carcinoma of the proximal transverse colon was confirmed at operation.



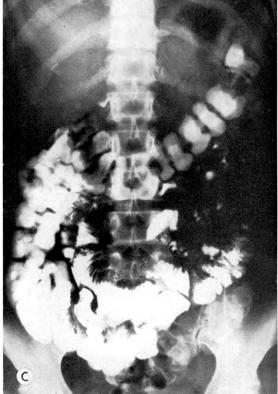


Fig. 11. Case No. A3715. Studies of the small intestines with a mixture of barium sulfate suspension and a 25 per cent hypaque solution. Note the separation of the 2 contrast media as they proceed in the intestines. (A) Roentgenogram made 20 minutes after oral administration of the barium-hypaque mixture. The stomach, duodenum and proximal jejunum are well visualized. Note the beginning of slight separation of hypaque in mid small intestines. (B) Roentgenogram made after 1 hour. Barium is still in the jejunum while most of the hypaque is in the distal half of the small intestines and the proximal colon. (C) At 4 hours barium is in mid small intestines while hypaque outlines the distal ileum and the greater portion of the colon.

Such obstruction is often found to be partial when re-examined with hypaque enema; and (3) in patients with known diverticulitis or recent colon surgery where there is danger of impending perforation or the possibility of leakage.

Orally administered water soluble contrast media are indicated as a supplement to a routine enema examination of the colon, whenever with barium enema the colon is unsuccessfully or inadequately filled because of obstruction of the colon, partial or complete, or because of the patient's inability to retain the enema. The colon should be carefully evaluated on all delayed roentgenograms of patients who had received hypaque oral or gastrografin in a routine study of the upper gastrointestinal tract. Colon visualization under these circumstances is practically as good as when an enema has been administered. There is no danger of impaction or obstruction, as is possible when barium sulfate is used.

# CONTRAINDICATIONS

There are no known contraindications to the use of water soluble iodinated contrast media. The incomplete emptying of the colon following attempted evacuation results in an inadequate study of the mucosal pattern and precludes double contrast studies with air; however, the addition of lavema powder overcomes this difficulty to a great extent.

## SUMMARY AND CONCLUSION

The use of water soluble iodinated contrast media constitutes a significant advance in the study of the lower digestive tract. The colon may be examined follow-

ing rectal administration of an enema, using 40 per cent hypaque solution, or oral administration of 40 per cent hypaque solution, gastrografin or gastrografin "improved." The techniques of examination are described. The advantage over the use of barium, as well as the safety is stressed and the limitations are mentioned. The addition of lavema powder to the hypaque enema enhances evacuation of the colon and eliminates in a large measure one of the limitations of this procedure. Study of the small intestine is still limited in scope.

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# FECALITHS OF THE APPENDIX: INCIDENCE AND SIGNIFICANCE\*

By DAVID FAEGENBURG, M.D.†

CINCE the initial report by Weisflog<sup>19</sup> in O 1906 of the roentgenographic diagnosis of a fecalith of the appendix, more than 150 cases have been reported and countless others detected. In a number of articles<sup>2,6,7,8</sup> a systematic effort was made to determine the actual incidence of demonstrable fecaliths in cases of acute appendicitis. If any criticism can be made of these excellent studies, it is that only a limited number of cases had had preoperative abdominal roentgenograms. Since only certain cases were subjected to abdominal roentgenography, it is reasonable to assume that some degree of selection was employed; the implication is that clinically equivocal or complicated cases were most likely to have required roentgen study. In a general discussion of the roentgen findings of appendicitis, Steinert et al.16 reported 104 cases, 98 of which had had abdominal roentgenograms. Their study has provided the most reliable information on the roentgenographic incidence of appendiceal stones in an unselected series.

The appendectomy material at this large Army hospital lends itself well to a consecutive-case study. Several reasons are submitted in support of this claim. First, there is on this post a large population of soldiers in the 17-30 age group and an equally sizable population of dependent children in the 0-16 age group. Thus, the number of cases of acute appendicitis is unusually high, averaging approximately 100 cases per year. Secondly, all appendectomy specimens, whether removed for appendicitis or incidentally to other surgery, are subjected to careful pathologic scrutiny. Furthermore, the number, size and location of all coproliths are stated in the pathologic report. Thirdly, and most important, it has been the policy of the Department of Surgery to obtain preoperative roentgenograms of the abdomen in all cases of suspected appendicitis, except when precluded by the condition of the patient. Thus, 94 per cent of the appendicitis cases in this study have had the benefit of preoperative roentgen evaluation.

# MATERIAL AND METHODS

One hundred consecutive cases of appendicitis, representing slightly less than 13 months' experience, comprise the pathologic material for this study. In 94 of these cases, adequate abdominal roentgenograms were available. These were studied for the presence or absence of fecaliths; other striking findings were also noted. The operative and pathologic reports were then studied and note made of all fecaliths. Careful study was made of the roentgenograms of those cases in which fecaliths were present at surgery but were not seen on the roentgenographic review. It is interesting to note that no additional fecaliths were detected by this method. It is even more noteworthy that every fecalith detected in this retrospective study had been mentioned in the original roentgenographic reports in spite of the fact that these reports had been rendered by 3 different radiologists. The entire series of 94 roentgenograms was then shown to a fourth radiologist who failed to detect a coprolith in only I of 12 positive cases. One may conclude, therefore, that visible fecaliths are detected reliably by trained observers. The results of this study are summarized in Table 1.

In an effort to determine the incidence of fecaliths in noninflamed appendices, 100 such cases, representing approximately 5 years' experience, were subjected to analy-

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sis. Fecaliths were present in 4 of these cases and, fortuitously, abdominal roent-genograms were available in these cases. The results of this study are summarized in Table II.

A comparison of the inflamed and non-inflamed groups is presented in Table III.

### INCIDENCE

The incidence of appendiceal fecaliths has varied widely from series to series. Kadrnka<sup>8</sup> reported an incidence of 4 per cent in 180 cases of appendicitis. Felson and Bernhard<sup>7</sup> found concretions in only 3 per cent of 300 cases. In a later communication, Felson<sup>6</sup> reported an incidence of 33 per cent in 75 roentgenographed surgical specimens, and basing his opinion on the radiopacity of the fecaliths, predicted that 12 per cent would be visible on roentgenograms. Steinert et al.<sup>16</sup> demonstrated fecaliths in 10 per cent of 104 cases of appendicitis.

The study described in this paper revealed that 12 per cent of appendicitis cases showed roentgenographically visible fecaliths, closely approximating the results of Steinert et al. and corresponding exactly to the prediction of Felson. An additional 5 per cent of cases had fecaliths that were roentgenographically undetectable.

The above figures are at striking variance with the findings in noninflamed appendices. Felson<sup>6</sup> demonstrated an actual incidence of 2.7 per cent in such organs and

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TABLE I
ACUTE APPENDICITIS

No. of cases	100
Roentgenograms available	94
No. of fecaliths	17
Fecaliths seen on roentgenograms	12
Fecaliths not seen	5
Other findings:	
Localized ileus	20
Generalized ileus	I
Scoliosis	2
Gas in appendix	I
Peri-appendiceal mass*	3
Fecaliths not seen Other findings: Localized ileus Generalized ileus Scoliosis Gas in appendix	5 20 1 2

<sup>\*</sup> Two cases with peri-appendiceal masses also showed fecaliths.

TABLE II
NONINFLAMED APPENDICES

No. of cases	100
Total no. of fecaliths	4
Fecaliths seen on roentgenograms	I
Other findings:	
Enterobius vermicularis*	I
	•

<sup>\*</sup> Associated with fecalith not seen on roentgenograms.

predicted that I per cent of normal appendices would contain roentgenographically detectable fecaliths. Again, these data correspond closely to the current study in which 4 per cent of noninflamed organs contained fecaliths and in which only I per cent contained fecaliths demonstrable by roentgen study. Thus, it may be stated that detectable fecaliths are associated with acute appendicitis about 10 to 12 times as often as with noninflamed organs. It follows that the discovery of a radiopaque fecalith in a patient with abdominal pain indicates at least a 90 per cent chance of acute appendicitis being present.

# PATHOGENESIS

While there is an unquestioned relationship between fecaliths and inflammatory conditions of the appendix, there is considerable debate concerning which is the cause and which is the effect. During the first three decades of this century, when the diagnosis of chronic appendicitis was much in vogue, it was widely held that low grade infection was responsible for the formation of appendiceal concretions. In the light of present knowledge, this seems most unlikely. The fecalith-bearing "normal" appendices reported in the author's series

Table III

COMPARISON OF INFLAMED AND NONINFLAMED

APPENDICES

	Cases	Fecalith Present	Fecalith Seen
Acute appendicitis Noninflamed appen-	100	17 (17%)	12 (12%)
dices	100	4 (4%)	1 (1%)

showed no microscopic evidence of chronic inflammatory reaction. Parenthetically, one case showed pinworms in the appendix; however, the relationship of helminthic infestation to fecalith formation is not fully understood.

In all likelihood, fecaliths originate from the inspissation of fecal material. Lowenberg10 states that the nucleus may contain hair, seeds, worms, flukes, fragments of shell and even metallic foreign bodies. The inspissated nidus causes irritation of the mucous glands in the crypts of Lieberkühn. Mucus, rich in calcium phosphate, precipitates on the fecal nucleus, frequently producing several layers of varying mineral content.2 When the concretion reaches a critical size, pressure atrophy of the mucous glands brings the process to a halt. The resultant obstruction of the lumen, plus the local irritative effect of the fecalith, eventually gives rise to an acute inflammatory process. The alarming incidence of gangrene and perforation is attributable to the high intraluminal pressure distal to the obstruction.

The chemical composition of appendiceal stones is entirely in keeping with this etiologic theory. According to Maver and Wells, 11 the average fecalith is composed of about one-fifth organic residue, one-quarter inorganic phosphate and slightly more than one half fats and fat derivatives, such as soaps, coprosterol and cholesterol.

# REPORT OF CASES

The following 3 cases illustrate the remarkable degree to which the mineral content of fecaliths determines their relative detectability.

Case I. C. McC., a 25 year old male, was admitted with a history of periumbilical and right lower quadrant pain of 12 hours' duration. He complained of nausea and had vomited several

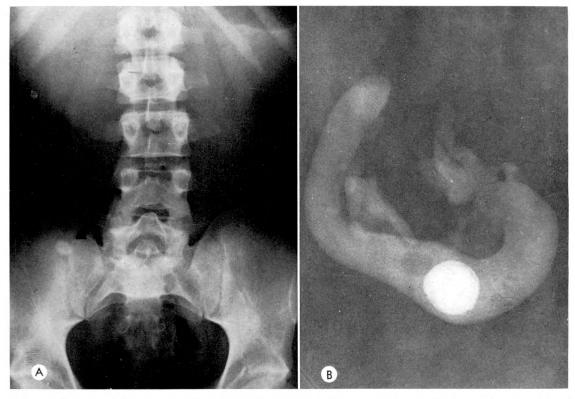


Fig. 1. Case I. (A) Supine roentgenogram of the abdomen showing a dense fecalith overlying the right sacroiliac joint. (B) Specimen roentgenogram showing extremely dense fecalith.

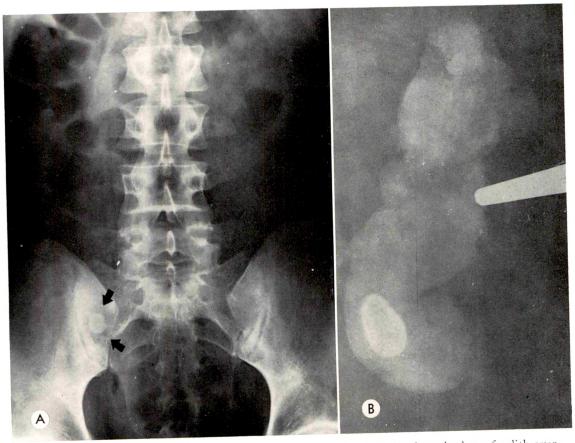


Fig. 2. Case II. (A) Supine roentgenogram of the abdomen showing a moderately dense fecalith overlying the right sacral wing. (B) Specimen roentgenogram showing fecalith of average density.

times. Physical examination revealed marked tenderness and involuntary muscle guarding in the right lower abdomen. The leukocyte count was elevated to 13,800. Supine (Fig. 1A) and erect roentgenograms of the abdomen revealed a well-defined, highly calcified density in the right lower quadrant; this was interpreted as a fecalith of the appendix. The patient was taken to the operating room and an acutely inflamed appendix was removed. The specimen (Fig. 1B) had a slightly irregular fecalith completely obstructing the lumen of the appendix. The pathologic diagnosis was acute appendicitis and peri-appendicitis.

Case II. H.S., a 32 year old male, was admitted with a history of cramping abdominal pain, nausea and vomiting of 24 hours' duration. The patient had been examined in the Emergency Room 12 hours previously and had been treated for gastroenteritis. He failed to respond to treatment and he returned to the

Emergency Room, complaining of pain localized to the right lower quadrant. On physical examination, tenderness, guarding and rebound tenderness were elicited in the right lower quadrant. The white blood cell count was 14,800 with 75 per cent neutrophils. Supine (Fig. 2 A) and erect roentgenograms of the abdomen revealed a laminated density in the right lower abdomen; this was felt to be a typical fecalith. The patient was taken to the operating room and a gangrenous appendix was removed. The fecalith was partially occluding the lumen (Fig. 2 B). The pathologic diagnosis was acute appendicitis with appendiceal ectasia.

Case III. R.C., a 24 year old male, was admitted with a history of right lower quadrant abdominal pain of 20 hours' duration. Physical examination revealed rebound tenderness in the right lower abdomen. The white blood cell count was 21,000. Abdominal roentgenograms were negative. On the day of admission, the pa-

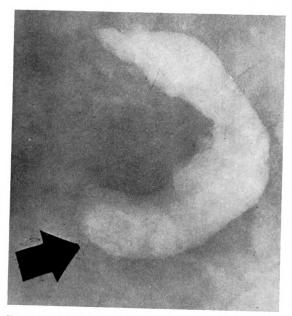


Fig. 3. Case III. Specimen roentgenogram showing faintly calcified fecalith. This fecalith was not detectable on the abdominal roentgenograms.

tient underwent laparotomy. A gangrenous appendix was removed. A fecalith was palpable in the appendix (Fig. 3). The pathologic diagnosis was acute gangrenous appendicitis.

The following case illustrates an unusually low-lying appendix containing several fecaliths.

Case IV. L.F., a 23 year old male, was admitted with a history of crampy lower abdominal pain of 24 hours' duration. He also complained of nausea, vomiting and diarrhea. Physical examination revealed right lower quadrant tenderness, guarding and rebound. The white blood cell count was 24,000 with 75 per cent neutrophils. Supine (Fig. 4 A) and erect roentgenograms of the abdomen demonstrated several laminated densities within the curve of the right pelvic brim. These were interpreted as fecaliths in a low-lying appendix. The patient was operated on and a large, bulbous, acutely inflamed appendix was removed. Several fecaliths were present (Fig. 4 B). The pathologic diagnosis was acute appendicitis.

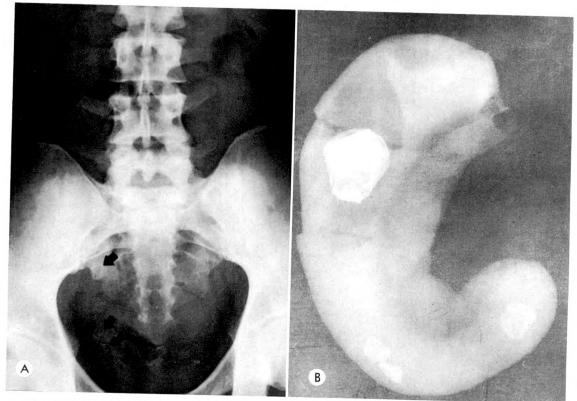


Fig. 4. Case IV. (A) Supine roentgenogram of the abdomen showing 3 opacities in the pelvis. (B) Specimen roentgenogram shows 4 fecaliths, 3 of which are well calcified.

The following case illustrates a fecalith which had been extruded from a perforated appendix.

CASE v. G.F., a 23 year old male, was admitted with a history of right lower quadrant pain of 4 days' duration. There had been slight nausea associated with this. Physical examination revealed guarding and rebound tenderness in the right lower abdomen. The white blood cell count was 17,000 with a normal differential. The abdominal roentgenograms revealed a large opacity, 2×1.5 cm., overlying the right second sacral segment (Fig. 5). This was interpreted as a probable fecalith, although the possibility of a large ureteral calculus was not excluded. The patient was operated on and a perforated appendix was found. There was a large abscess cavity in which the fecalith was located (Fig. 5, insert). The pathologic diagnosis was acute appendicitis with perforation.

The following case illustrates a dense fecalith in a noninflamed appendix.

CASE VI. D.W., a 42 year old female, was admitted with a history of intermittent right upper quadrant pain of I year's duration. The patient also complained of intolerance to fatty foods. Physical examination revealed minimal tenderness on deep palpation of the right upper quadrant. Standard and double dose gallbladder studies demonstrated nonopacification. On both studies, a laminated triangular density was present in the right lower abdomen (Fig. 6). This had also been present on a gastrointestinal series 9 months previously but had not been reported. The roentgenimpression was nonvisualization of the gallbladder and fecalith in the appendix. The patient underwent cholecystectomy. The appendix was removed. The pathologic report was, vermiform appendix and fecalith, with no pathologic diagnosis.

# ROENTGEN FINDINGS

The characteristic finding is one or more laminated densities, 5 to 20 mm. in diameter, usually located within a 15 cm. radius of the mid-point of the right iliac crest. The extremes of size are 2 mm. and 40 mm. While 70 per cent are solitary, in approximately one-fifth of cases 2 fecaliths are seen and in one-tenth of cases 3 or more are present. As many as 23 have been ob-

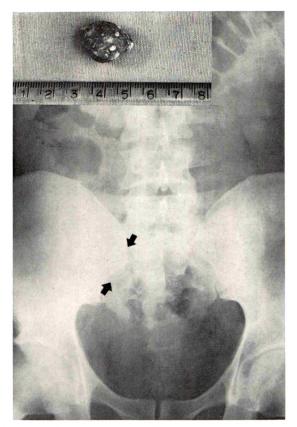


Fig. 5. Case v. Supine abdominal roentgenogram showing fecalith overlying the sacrum. *Insert*. Photograph of fecalith recovered from peri-appendiceal abscess.

served.<sup>13</sup> The majority are oval, but round, rectangular, triangular and irregular shapes are frequently encountered. About three-fourths are laminated, the remainder being diffusely or granularly calcified. Lamination may be poorly appreciated on roent-genographic study, especially when the fecalith is superimposed over bone.

Unusual locations may cause confusion. The finding of a fecalith in the right upper quadrant is often attributable to a retrocecal appendix. In one report,<sup>3</sup> the fecalith was seen in the left upper quadrant, this unusual location being the result of malrotation of the colon. With perforation of the appendix, the coprolith may be extruded and may be at a considerable distance from the appendix.

There are several factors which may pre-



Fig. 6. Case vi. Abdominal roentgenogram showing laminated fecalith in the right lower abdomen. This concretion had been present for at least 9 months. There was no clinical or microscopic evidence of appendicitis.

vent roentgen visualization of a fecalith. The most common cause is a paucity of mineral content (Fig. 3). The current series contains one case in which extreme obesity obscured a faintly calcified body. Roentgenograms of poor quality, especially when underpenetrated, reduce the likelihood of detection. It is rare for a moderately well mineralized fecalith to be obscured by the ilium, sacrum or lumbar spine.

# SURGICAL SIGNIFICANCE

The presence of a fecalith in a case of appendicitis increases the likelihood of complications more than threefold. In numerous studies, <sup>2,3,6,7</sup> at least half of such cases were complicated by gangrene or perforation. These unfortunate complications were present in 12 of 17 cases in the author's

series. The perforations are always at the site of or distal to the fecalith.

In the pediatric age group, the danger of perforation is so great that Stiles<sup>17</sup> has stated, "When a radiopaque appendiceal coprolith is found in a child with abdominal symptoms, and other abnormalities have been ruled out, immediate surgery should be performed." Considering the annual mortality of 17,000 Americans from appendicitis and its complications, Stiles' comment might well apply to all age groups.

# THE ASYMPTOMATIC FECALITH

While there seems to be little doubt about the surgical importance of fecaliths in patients with abdominal pain, the course of action in asymptomatic patients with this finding is less clear-cut. The case for elective appendectomy is a strong one. Brady and Carroll<sup>3</sup> have reported several cases in which the chance finding of a fecalith was followed by acute appendicitis after a duration of several weeks to 2 years. This observation has been confirmed repeatedly.14,16,18 Thomas,18 in a pungent commentary on this problem, reminds us of the universal practice of operating for asymptomatic gallstones, surely a less serious threat to the life of the patient. The risks of elective appendectomy are far outweighed by the probability of future perforation.

# DIFFERENTIAL DIAGNOSIS

The most important differentiation is from right ureteral calculus. Excretory urography will usually exclude this entity. However, a marked peri-appendicitis may cause right ureteral obstruction. A fecalith can almost always be separated from the ureter in oblique projections.1,5 Bone islands in the ilium can be differentiated by multiple views or stereoscopy.6 Mesenteric lymph nodes are more mobile and are granularly calcified. Gallstones may be quite difficult to distinguish from fecaliths in a retrocecal appendix. Cholecystography by oral or intravenous routes may be necessary. On rare occasions, appendicoliths may be confused with opaque pills, phleboliths, concretions in Meckel's diverticulum and calcified appendices epiploicae.

### CONCLUSIONS

- 1. The presence of a fecalith is a highly specific confirmatory sign in the diagnosis of acute appendicitis.
- 2. The chance finding of a fecalith in an asymptomatic patient is an indication for elective appendectomy.
- 3. In view of the diagnostic specificity of the fecalith sign, routine abdominal roentgenography is justified in cases of suspected appendicitis.

# SUMMARY

- 1. One hundred cases of acute appendicitis were compared with 100 cases of noninflamed appendices. In the abnormal series, there were 17 fecaliths, of which 12 were roentgenographically detectable. In the normal series, there were 4 fecaliths, of which I was roentgenographically detectable.
- 2. Seventy per cent of the inflamed appendices containing fecaliths were gangrenous or perforated.
- 3. Fecaliths were detected reliably and without difficulty by a number of trained observers.

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# ROENTGEN MANIFESTATIONS OF PRIMARY AMYLOIDOSIS OF THE COLON

# CASE REPORT

By MAX RITVO, M.D.,\* and CONRAD LITNER, M.D.†

AMYLOIDOSIS is relatively rare. Involvement may be localized or widespread, and practically any organ of the body may be affected. Clinical diagnosis is difficult as symptoms are frequently entirely absent and when present are not characteristic. The existence of the condition may be suspected on the basis of the laboratory data, establishment of a definite diagnosis being dependent on microscopic study of a specimen obtained at biopsy or operation, or postmortem examination. The gastrointestinal tract is the second most frequent site of the disease. Matthews<sup>10</sup> reviewed the literature and found the incidence of amyloidosis of the various portions of the alimentary canal to be as follows: stomach, 39 per cent; small bowel, 37 per cent; esophagus, 23 per cent; and colon 33 per cent. In his series, only 30 per cent of the cases were diagnosed prior to postmortem examination as most of the patients presented few if any symptoms.

The roentgen findings in amyloidosis affecting the stomach and small intestine have been described in detail in several communications. 1-12 Despite the fact that involvement of the colon occurs in a high percentage of the patients with gastrointestinal amyloidosis, the literature contains few descriptions and no actual illustrations of the roentgen changes which may occur in the bowel in the disease. In view of this, it was deemed worthwhile to record a case in which primary amyloidosis of the colon was associated with extensive alterations which were clearly demonstrable on barium enema study. A feature of particular interest is that the roentgen manifestations in our patient simulated those in ulcerative colitis and the patient for a period of several years was erroneously diagnosed as having this disease until the correct diagnosis was established.

### REPORT OF A CASE

The patient was a 22 year old white female who had been in good health until the age of 17 at which time she began to have bloody diarrhea and abdominal pain which continued for about 3 months. An appendectomy was performed with subsidence of the symptoms. After an interval of several weeks, the symptoms recurred. Since that time she had attacks of severe diarrhea with 8 or 9 loose bowel movements daily. The stools were green and contained blood and mucus. She had 3 pregnancies. The diarrhea and pain disappeared during the last half of each of the pregnancies only to recur after an interval of a few months post partum. During the previous 5 years she had been treated at several hospitals for "ulcerative colitis" but without beneficial results.

The patient was born in Boston, Massachusetts, and had never been out of New England. She was an average smoker but denied consumption of alcohol. Her appetite was very poor and she had been eating sparingly for several years since the ingestion of food aggravated the diarrhea and severe abdominal pain was experienced during defecation. There was considerable weight loss during this period, her weight ranging from 120 pounds 5 years ago to 90 pounds at the time of the present hospital admission. The past history included German measles but no scarlet fever, rheumatic fever, tuberculosis, diphtheria, or pneumonia. Menses began at the age of 12 years and have been regular. There were no known allergies. She had noted a tendency to bruise easily for a considerable period of time.

Physical examination revealed a pale, thin, chronically ill, white female. The blood pressure

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was 104/70, temperature 99.6° F., pulse 92, and respirations 16. The skin was of poor turgor and elasticity. Several small lymph nodes were palpable in the posterior cervical region. The breasts were poorly developed; no masses or tenderness were present. The trachea was in the mid-line. The lungs were clear to percussion and auscultation. The heart was not enlarged. A Grade II, basal, blowing systolic murmur with maximal intensity at the aortic and pulmonic area and which radiated along the left sternal border and into the neck was present. A2 was greater than P2. The liver was enlarged, the lower edge being palpable 4 cm. below the right costal margin. The spleen was normal in size. The abdomen was not protuberant. Moderate edema of the lower extremities and slight clubbing of the fingers were present.

The white blood cell count was 12,500, with 62 per cent polymorphonuclears, 37 per cent lymphocytes, and I per cent monocytes. The red blood cell count was 3,300,000, with slight hypochromia and normocytosis. The hematocrit was 35 per cent, and the hemoglobin 10.5 gm. per cent. The sedimentation rate was 53 mm. per hour. Urinalysis revealed 3+ proteinuria with 8 gm. of protein in the urine during a period of 24 hours. The blood urea nitrogen was 10 mg. per cent; carbon dioxide 26.4 mEq./L.; chlorides 101 mEq./L.; sodium 145 mEq./L.; potassium 3.4 mEq./L.; calcium 6 mEq./L.; phosphorus 4.4 mg. per cent; cholesterol 326 mg. per cent; and alkaline phosphatase 2.6 Bodansky units. The stools were guaiac negative. Liver function tests showed a 4+ cephalin flocculation; bilirubin 0.5 mg. per cent; prothrombin time 14.4/13.8 seconds; and the phenolsulfonphthalein excretion test 65 per cent in 2 hours (normal). Total protein was 3.4 gm. per cent with a hypoalbuminemia of 1.7 gm. per cent. Alpha 2 globulins and beta globulins were increased. The dextroxylose test was within normal limits. The Evans blue test (which corresponds to the Congo red test) showed findings not consistent with secondary amyloidosis.

On proctosigmoidoscopy the rectal mucosa appeared pale, slightly edematous and granular, but was not friable or ulcerated. A left renal biopsy was performed and established the presence of amyloid nephrosis. Biopsy of the rectosigmoid showed amyloid deposits in the wall of the large bowel vessels and the cresyl-violet and Congo red stains were positive for amyloid.

The diagnosis was proteinuria, hepatomegaly, and amyloidosis with nephrotic syndrome.

### DISCUSSION

Amyloidosis is defined as the pathologic condition characterized by the deposition of amyloid within the tissues of the body. Amyloid is a glycoprotein, a mucopolysaccharide-protein complex, which is optically homogeneous, translucent, and hyalin-like. It is deposited in the intercellular spaces rather than within the cells. Robbins<sup>11</sup> states that it is distinguishable from other hyalin substances by its special staining properties (positive reaction to Congo red dye and metachromatic with crystal violet), specific sites of deposition, and close association with certain specific clinical states.

Amyloid may be found in virtually any organ of the body and in a variety of clinico-pathologic conditions. There are 4 distinctive patterns which lend to its classification:<sup>11</sup> (1) secondary amyloidosis; (2) primary amyloidosis; (3) amyloidosis associated with multiple myeloma; and (4) isolated amyloidosis.

- (1) Secondary amyloidosis refers to the occurrence of amyloid deposits in patients with long-standing disease in which there is tissue breakdown and destruction such as occurs in: (a) chronic suppuration affecting any organ as, for example, chronic osteomyelitis; (b) long-standing tuberculosis or leprosy; (c) chronic arthritis, especially rheumatoid arthritis; and (d) far-advanced malignancy, leukemia, and lymphoma.
- (2) Primary amyloidosis refers to the occurrence of amyloid deposition in patients in the absence of any underlying clinical disease associated with amyloidosis; it is distinct from the other forms clinically and in its distribution, although the morphologic characteristics are almost identical and cannot be differentiated.
- (3) Amyloidosis associated with multiple myeloma. There is an incidence as high as 30 per cent of cases of multiple myeloma which are complicated by amyloidosis.
  - (4) Isolated amyloidosis refers to a single

focus of amyloid deposition in any of the organs involved in the primary form of the disease.

Amyloid degeneration is classified among the group of collagen diseases because it affects the ground substance of connective tissue primarily and not the parenchyma of an organ, although the latter may undergo secondary changes. It is deposited between the basement membrane and the endothelial lining of the capillaries and the tiny arterioles, which become decreased in caliber and eventually are completely obliterated. The kidneys, liver, spleen, adrenal glands and gastrointestinal tract are the principal sites of involvement, although the disease is widespread and no organ of the body is immune. Organs derived from mesenchymal origin, i.e., the skeletal musculature including the tongue and the musculature of the gastrointestinal tract, are most frequently involved in the primary form of the disease.

#### PATHOLOGY

Infiltration of the colon in amyloidosis is usually less marked than elsewhere in the gastrointestinal tract. The gross pathology in the large bowel consists basically of thickening of the muscle layers and nodularity of the mucosa and submucosal layers associated with transverse ridging and is similar to the changes which occur in the small intestine. Stenosis of the sigmoid has been described. Necrosis and ulcerations have been reported in the lower rectum, with evidence of amyloid in the ulcers. On microscopic examination, amyloid is found in the small and medium sized blood vessels of the submucosa, less often in the serosa, and frequently in the intima. The blood vessels are irregularly thickened by pinkstaining, nodular masses of amyloid. Giant cells may occur at the periphery of the amorphous collections. The smooth muscle bundles in the outer walls of the muscularis and the muscularis mucosae may be atrophic, in some instances being replaced completely by amyloid. Scattered foci of amyloid occur principally in the circular muscle

layer although they may be present also in the longitudinal muscle coats. The areas may become confluent and extend from the submucosa to the serosa. Nerve plexuses in the submucosa may be involved and may be replaced by amyloid. Occasionally, subperitoneal amyloid masses are present.

# LABORATORY DIAGNOSIS

Laboratory tests helpful in making the diagnosis of amyloidosis include the following:

- (1) Congo red test. In patients with amyloidosis this dye disappears faster from the serum than in normal individuals. A serum retention of less than 20 per cent is strongly indicative of the presence of this disease.
- (2) Gingival biopsy. This is positive more often in primary amyloidosis and in cases associated with multiple myeloma.
- (3) Needle or open biopsy of the organ suspected of involvement such as the liver, kidney, spleen, and skin is essential. Biopsy of the rectum or rectosigmoid affords one of the most definitive means of establishing the diagnosis.

# ROENTGEN FEATURES

The patient considered in this report had several roentgen studies of the colon during a period of more than 4 years. The first was in June, 1957 (Fig. 1A). At this time, barium enema examination showed markedly diminished haustrations in the transverse and descending portions of the colon. Numerous deep indentations were present along the lateral border of the ascending colon. Throughout the colon, there were multiple superficial irregularities of outline interspersed with small projections from the lumen; the latter were widely spaced, lacked uniformity, and did not have a serrated appearance. The postevacuation roentgenogram (Fig. 1B) showed almost complete emptying of the colonic contents. There were multiple deep indentations in the right colon as were previously. The mucosa of the large bowel was abnormal in appearance with thickened folds and coarse nodularity.

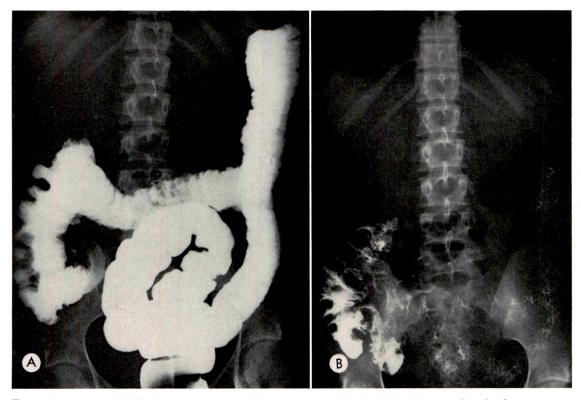


Fig. 1. June, 1957: (A) Barium enema study. There are markedly diminished haustrations in the transverse and descending portions of the colon. Throughout the bowel, there are scattered areas or irregularity of outline interspersed with superficial projections from the lumen. (B) The postevacuation study is characterized by very extensive emptying of the opaque material. The mucosa throughout the colon presents an abnormal appearance with thickening of the folds and a coarse, nodular pattern.

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In May, 1959, the colon was atonic (Fig. 2). The transverse and descending colon were ahaustral. The ascending colon presented diminished haustrations and an area of poor filling involving the lateral aspect in the region proximal to the hepatic flexure.

In October, 1961, there were present in the ascending and transverse colon multiple areas of luminal narrowing alternating with areas of slight widening (Fig. 3A). The middle and lower thirds of the descending colon were ahaustral. There were multiple

Fig. 2. May, 1959: Barium enema study. The transverse and descending colon are ahaustral. There is irregularity of outline involving the inferior aspect of the middle third of the transverse colon. There is atonicity and a tubular appearance in the descending colon.



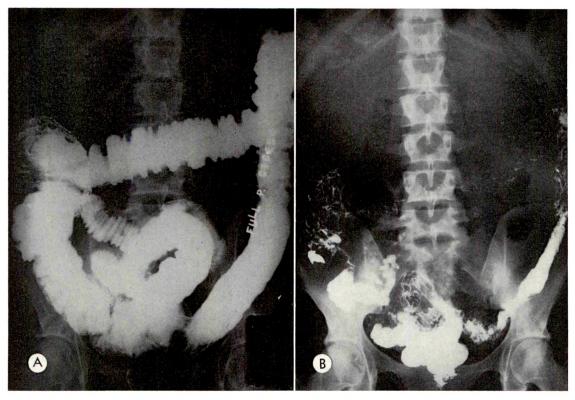


Fig. 3. October, 1961: (A) Barium enema study. The ascending and transverse portions of the colon show areas of narrowing and incomplete filling which on roentgenoscopy were found to be inconstant and variable. The descending colon and sigmoid are tubular in character, ahaustral, and present numerous superficial projections from the lumen. (B) Postevacuation study. Only small amounts of the opaque material are retained in the colon. The mucosa is abnormal in appearance, the folds being coarse and nodular.

shallow projections from the lumen of the colon; these were most clearly evident in the transverse colon and the inferior portion of the descending colon and were distributed in irregular fashion. The caliber and length of the colon were not remarkable. The postevacuation study (Fig. 3B) showed extensive emptying. The mucosal pattern was thickened with a coarse, nodular pattern.

The differential diagnosis must include ulcerative colitis, tuberculosis, amebiasis, regional enterocolitis, diverticulitis, polyposis, deficiency states, neoplasm, and allergic colitis. The condition which is most apt to be confused with amyloidosis of the colon is ulcerative colitis. In the early stages of ulcerative colitis, there are alterations in the mucosa, the folds being irregular and tending to be parallel rather than extending

irregularly in various directions. The characteristic manifestation is the presence of multiple minute serrations along the margins of the large bowel; these are closely spaced and represent superficial ulcerations. As the disease progresses, submucosal abscesses may result from extension of the ulcers, producing rounded areas of increased density adjacent to the lumen of the colon due to penetration of the opaque medium into the muscular coats. Longstanding, chronic cases of ulcerative colitis are characterized by distortions of the mucosal pattern, loss of haustrations, and decrease in the size and caliber of the bowel producing the so-called tubular colon. Destruction of the mucosa results in the replacement of the normal mucosal pattern by longitudinal striae. Multiple polyps are frequently present and produce intraluminal mottlings. The postevacuation opaque enema study shows narrowing and rigidity of the colon with absence of the mucosal pattern.

The roentgen manifestations in ulcerative colitis as well as in the other conditions which must receive consideration in differential diagnosis bear a superficial resemblance to those which occurred in the patient with amyloidosis described in this report. Careful analysis of the findings will aid in establishing the correct diagnosis.

# SUMMARY AND CONCLUSIONS

Since amyloidosis often occurs without producing symptoms and seldom, if ever, presents characteristic manifestations, clinical diagnosis is impossible as a rule. Consequently, many cases continue undiagnosed for long periods of time, often throughout the entire lifetime of the patient. If the condition is misdiagnosed as ulcerative colitis, tuberculosis of the colon, or other similar disease, unnecessary or improper therapeutic measures may be instituted.

Involvement of the colon is present in a high percentage of patients with amyloidosis of the gastrointestinal tract. Biopsy of the rectosigmoid affords one of the most definitive means available to establish the diagnosis of the disease. The roentgen findings in our patient bore certain resemblances to those which are found in ulcerative colitis. However, colitis is usually associated with multiple closely-spaced, superficial serrations, shortening of the colon and narrowing of the lumen with absence of haustral markings which impart a tubular appearance to the bowel, none of which were present in our patient. The patient showed no evidences of ulcerative colitis on pathologic examination, although for a period of over 5 years she was erroneously believed to be suffering from the disease.

As with other rare and little known diseases, amyloidosis of the colon will not be diagnosed correctly unless the possibility of the disease is borne in mind, its manifestations understood, and it is given full consideration in the differential diagnosis of every case of bowel disturbance with atypical and unusual changes.

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# LEIOMYOSARCOMA OF THE COLON\*

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LEIOMYOSARCOMA of the colon is an uncommon tumor, only 23 cases having been previously described. The purpose of this article is to report an additional case and to review the clinical, pathologic and roentgenologic findings of this process.

This report does not include leiomyosar-coma of the rectum, which occurs at least twice as frequently as in the colon. Rectal leiomyosarcomas are highly malignant, and combined abdominoperineal resection is the treatment of choice. 2.8

# CLINICAL FINDINGS

Age. No age group is immune. The age of reported cases varied from the neonatal period to 78 years. The incidence in younger patients is rather high. Of 13 cases in which the age was given, 6 patients were 27 years of age or less. Of these, 2 were less than 4 months of age.

Sex. There is no sex predominance. Of 12 cases in which the sex was listed, 5 were males and 7 were females.

Duration of Symptoms. The reported cases showed a considerable variation in the duration of symptoms but most often there was a I to 6 month history. MacKenzie et al.8 in their series encountered 5 patients with a history of 2 to 6 months' duration; symptoms of a few weeks occurred in 4 patients; in I case symptoms were present at birth; and in another, there were no symptoms prior to perforation. One patient gave a history of vague symptoms for a period of 10 years and acute symptoms for IO days, while a 3 year history was apparently present in 2 cases.

History and Physical Examination. On physical examination, an abdominal mass is by far the most frequent finding. This may be fixed or mobile and is often painful and tender. Abdominal pain is a prominent symptom. Nausea and vomiting may occur. In I instance, the original diagnosis was appendicitis.<sup>14</sup> Bowel habits are variable, and there may be no change. Both constipation and diarrhea have been described, and in I case there was diarrhea which was followed by constipation. Blood in the stools may be either frank or occult in nature. In I instance rectal hemorrhage and shock developed, but this was apparently precipitated by a barium enema examination.9 Passage of mucus per rectum is occasionally noted. Weight loss is not common and, when present, is usually minimal. Other symptoms and physical findings may be due to obstruction, perforation, or intussusception.

There are no specific clinical features to differentiate between benign and malignant smooth muscle tumors; however, a rapidly enlarging abdominal mass suggests malignancy.

Laboratory Data. Anemia, presumably secondary to bleeding from the ulcerated neoplasm, is not infrequent. Hemoglobin values as low as 6 gm. 4 and 50 per cent 12 have been reported. Fever and leukocytosis may occur due to secondary infection.

## PATHOLOGY

Leiomyosarcomas of the colon are usually over 5 cm. in size, and tumors measuring 8 to 10 cm. are not infrequent. The largest tumor described was the size of a 6-month fetus. The size, however, cannot be used as a criterion of malignancy, since benign leiomyomas may also attain a large size.

These tumors have been found in the sigmoid and transverse colon, 6 cases having been described in each location. The cecum

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and ascending colon have each been the site of 4 cases. One case each has been described in the hepatic flexure, splenic flexure, descending colon, and appendix.

There are 4 gross types: submucosal, subserosal, combined, and constrictive. The submucosal (intracolic) type is apt to be associated with ulceration, pain, intussusception or obstruction. The subserosal (exocolic) type grows into the abdominal cavity and may communicate with the lumen of the bowel after central necrosis. The combined ("dumbbell") variety consists of both submucosal and subserosal components. The intramural (constrictive) type involves the wall of the colon with subsequent narrowing of the lumen.

Ulceration is common and may be quite extensive, especially if due to central necrosis. Secondary infection may occur. Intussusception has been described, 8,12,15 as well as perforation into the abdominal cavity.8

Liver metastases are not uncommon. Involvement of the peritoneum and regional lymph nodes may occur. Metastatic spread to the lungs and other distant organs is rare but does occur.

According to Golden and Stout,<sup>3</sup> histologically the leiomyosarcoma may appear similar to normal smooth muscle cells and yet be clinically malignant. Conversely, the presence of bizarre or monster cells does not necessarily indicate malignancy. The best histologic criterion of malignancy is the presence of a large number of mitoses, especially if there are 2 or more per high power field. However, a tumor may be clinically malignant and reveal only minimal numbers of mitoses.

# ROENTGEN FINDINGS

Changes similar to those found with leiomyosarcoma elsewhere in the gastro-intestinal tract could be expected. However, there are only 6 previously published cases containing illustrations of the roent-gen findings.<sup>1,2,4,5,9</sup> One case appeared to be of the dumbbell type.<sup>1</sup> The tumor measured 9.5×4.8×6.6 cm. and was mostly extra-

luminal. There was I example of the constrictive type.2 A filling defect, which was longer than the usual carcinoma, was present. There were abrupt "shelf-like" margins at the edges of the tumor. Two cases4,9 were clearly of the intracolic type. There was some associated narrowing of the bowel lumen, presumably due to the large size of the tumors (12 cm. and 10.5 cm.). In another case<sup>5</sup> of the intracolic type, there was evidence of intestinal obstruction. Since the tumor measured only 5 cm. in diameter, a constrictive element was probably also present. This tumor was visualized as a soft tissue mass in the left upper quadrant on plain roentgenograms of the abdomen. There was distention of the small bowel and proximal colon due to obstruction. A "claw-like" defect at the splenic flexure was noted on a progress roentgenogram following a barium meal. The tumor was also visualized as an obstructing lesion on the barium enema study.

# PROGNOSIS

The leiomyosarcoma is usually of low-grade malignancy. The term "malignant leiomyoma" has been proposed as more appropriate, since the word "sarcoma" suggests a greater degree of malignancy.<sup>3</sup>

The treatment is the same as for carcinoma. If the leiomyosarcoma is resected early enough, the prognosis is fair and probably somewhat better than for the average carcinoma. The prognosis is less favorable if the histologic pattern indicates a poorly differentiated tumor with numerous mitotic figures.

# REPORT OF A CASE

A.S., a 63 year old white female, was admitted on July 26, 1961 with lower abdominal pain of 4 weeks' duration. One day prior to admission blood had been noted in the stool. There was no diarrhea or constipation.

Physical Examination. The abdomen was soft. Some lower abdominal tenderness was present but no mass was palpated. No other significant findings were noted.

Laboratory Findings. The hematocrit was 37 per cent; hemoglobin 12.4 gm.; and the

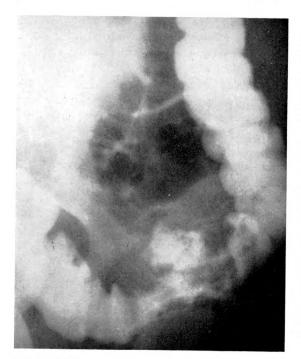


Fig. 1. Oblique roentgenogram of barium-filled sigmoid showing a large ulcer crater with localized narrowing of the colon in this region.

white blood cell count revealed 6,900 leukocytes, with 90 per cent neutrophils, 5 per cent lymphocytes, 4 per cent monocytes, and 1 per cent basophils.

Roentgen Findings. Chest roentgenograms showed residua of minimal fibroid tuberculosis in the left apex. Gallbladder and upper gastrointestinal studies were normal. On barium enema examination there was narrowing of the sigmoid colon near its junction with the transverse colon. The lumen of the bowel in this area was narrowed approximately 50 per cent. This extended a distance of 6 cm. There was a biconcave "shelf" which sharply delineated the narrow area from the normal colon. On the superior margin of the midportion of the narrowed area, there was a large collection of barium resembling an ulcer crater. The ulcer measured 3 cm. in diameter and 3 cm. in depth. The findings were interpreted as representing an ulcerated neoplasm of the sigmoid colon (Fig. 1 and 2).

Surgical Findings. Surgery performed on August I, 1961 disclosed a firm, nodular mass in the sigmoid colon at its junction with the descending colon, which measured approximately 3×6 cm. Further exploration revealed

two large lymph nodes, each  $2 \times 3$  cm., located just anterior to the spine in the para-aortic region. It was felt that these were metastatic. Exploration of the liver and other abdominal organs was not significant. Segmental resection of the tumor with end to end anastomosis was performed.

Pathologic Findings. The specimen consisted of a portion of large intestine measuring 10 cm. in length and 3 cm. in diameter. The serosal surface was smooth and shiny with slight puckering in the center. On opening the specimen, there was a large, sharply circumscribed ulcerated tumor mass, 4 cm. in diameter and 3 cm. in depth. The tumor involved approximately three-quarters of the circumference of the colon, and infiltrated the entire thickness of the wall. The base of the ulcer was covered by a large amount of grayish-yellow necrotic material. In the pericolic fat, several lymph nodes were found which measured up to 1 cm. in diameter.

Microscopic Findings. The characteristic ap-



Fig. 2. Posteroanterior roentgenogram of the sigmoid region. A tiny diverticulum along the lateral wall of the colon might suggest that the ulceration and narrowing could be due to diverticulitis; however, an abrupt tumor-like margin delineating the upper portion of the tumor with a characteristic biconcavity toward the tumor is demonstrated.

pearance of the tumor was present only in some areas, with strands of long oval cells with fusiform dark-staining nuclei. The cytoplasm in some cells was eosinophilic and the cells resembled smooth muscle cells. In most areas there was wild proliferation of very anaplastic cells. The cells showed extreme pleomorphism with huge, bizarre vesicular nuclei and many multinucleated and mitotic figures (Fig. 3 and 4). The entire thickness of the intestinal wall was infiltrated. There was extensive necrosis. Blood vessels in the pericolic fat contained tumor cells. The microscopic diagnosis was (1) leiomyosarcoma of the sigmoid colon; and (2) lymph nodes showing metastatic tumor.

Clinical Course. The patient was discharged from the hospital on August 18, 1961 still febrile and complaining of abdominal pain. The patient re-entered the hospital on September 7, 1961, complaining of abdominal pain and blood in the stool. Severe epigastric pain had been present for 12 hours. Both legs were swollen, the skin was cold and clammy, the abdomen was distended, and bowel sounds were hyperactive. Masses could be felt on rectal examination. The blood pressure was 70/50 and the pulse rate was 135. The red blood cell count was 2,470,000, with a hemoglobin of 6.6 gm. Hematocrit was 25 per cent. The patient received two blood transfusions, after which the hemoglobin rose to 9.3 gm. with a hematocrit of 30 per cent. However, the abdominal pain and distention became more pronounced. Severe diarrhea developed with brown and black stools. Marked lethargy occurred, and the patient went into profound shock. Death occurred on September 10, 1961, 41 days after surgery and approxi-



Fig. 3. Low power photomicrograph of tumor showing spindle-shaped cells forming interlacing bundles.

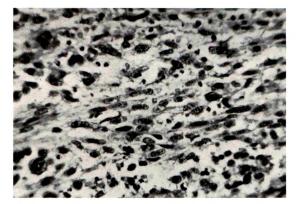


Fig. 4. High power photomicrograph showing large anaplastic sarcoma cells.

mately 10 weeks after the onset of symptoms.

Postmortem Findings. There was 2,000 cc. of purulent peritoneal fluid. Tumor nodules were scattered over the whole surface of the visceral and parietal peritoneum and also involved the mesentery and the omentum. In the area of the anastomosis, a 5 cm. defect in the bowel wall, which was partially sealed off by adherent loops of the small intestine, was noted. Through the opening, fecal material freely extruded into the peritoneal cavity. Microscopic sections from this area revealed infiltration of the entire thickness of the intestinal wall by the tumor with associated necrosis and perforation. In addition, there was a 12×18 cm. mass in the retroperitoneal area, encasing the aorta, renal arteries, and common iliac arteries. Metastases in the liver were prominent, the nodules ranging in size from 2 to 20 cm. The 20 cm. nodules were presumably due to coalescence of smaller lesions. Tumor nodules were noted on the pleural surfaces and in the pulmonary parenchyma. The autopsy findings were summarized as follows: (1) recent resection of bowel, with neoplastic involvement of the suture line with breakdown; (2) massive subacute and purulent peritonitis; (3) massive metastatic sarcoma of the liver, adrenals, lungs, kidneys, peritoneum, abdominal and retroperitoneal lymph nodes; and (4) acute purulent pyelonephritis of the left kidney.

# DISCUSSION

This case is interesting from several aspects. Clinically, this case proves that the leiomyosarcoma may progress quite rapidly; pathologically, it is of interest because pulmonary and other distant metas-

tases occurred. Also noteworthy are the liver metastases with nodules measuring to 20 cm. in size.

Roentgenographically, the finding most suggestive of leiomyosarcoma was the presence of a very large ulcer crater. This is not pathognomonic and may occur in other neoplasms, such as lymphomas and melanomas. Inflammatory disease and benign leiomyomas may also be associated with giant ulcers, but the presence of a narrowed segment with sharp biconcave margins (tumor "shelf") rules out a benign etiology.

# SUMMARY AND CONCLUSIONS

Leiomyosarcoma of the colon is an uncommon tumor. The most frequent finding is an abdominal mass of a few months' duration, associated with a variable amount of abdominal pain and melena. Roentgenologically, the correct diagnosis can be suspected by the demonstration of a colon neoplasm which is associated with a very large ulcer, with or without a large extraluminal mass.

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# MALIGNANT LYMPHOMA OF OVER FIFTEEN YEARS' DURATION MASQUERADING AS ULCERATIVE COLITIS\*

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NEW YORK, NEW YORK

In THE differential diagnosis of a case presenting clinically as nonspecific ulcerative colitis, with a roentgenographic picture of diffuse pseudopolypi formation, one is not likely to consider malignant lymphoma, particularly when the patient survives for 15 years. It is to call attention to such a possibility, however, that the following case of reticulum cell sarcoma of apparently greater than 15 years' duration, but misdiagnosed as typical ulcerative colitis, is presented. In a review of the English language literature of the past 34 years, the authors were unable to find a similar case report.

### REPORT OF A CASE

A 28 year old white female was first admitted to Montefiore Hospital, (Record No. 15940) on February 14, 1945, with a chief complaint of chronic diarrhea of 3 years' duration and blood in her stools of 4 days' duration.

The patient first had noted diarrhea as a post-breakfast occurrence in 1942. Early in 1943, at the time her husband was drafted, bowel movements had increased up to 3 or 4 times daily, but in between attacks of diarrhea she had no gastrointestinal complaints. Diarrhea had remitted for several months in 1943, with a recurrence for a few days when her husband was shipped overseas. She had done fairly well for the next year, but in January, 1945, she had begun to have lower abdominal tenderness and diarrhea 3 to 4 times daily and I to 4 times at night. For the 4 days prior to admission, the stools had been bloody, watery, with passage 4 to 8 times daily. There had been no tenesmus.

Social history: Noncontributory.

Family history: Her mother, aged 52, had tuberculosis in childhood and lately had cholecystitis and cholelithiasis.

Past history: The patient stated that she had always been healthy.

Review of systems: Completely negative except for a good deal of emotional stress.

Physical examination: The patient was a well-developed, fairly well nourished white female who looked dehydrated and acutely ill. She was quite apprehensive. The temperature was 102° F., pulse 120, blood pressure 106/64, and respirations 24. The only pertinent physical findings were slight enlargement of the cervical and inguinal lymph nodes which were not inflamed nor tender, marked abdominal tenderness in both lower quadrants—left greater than right—with no organomegaly or masses, and generalized tenderness throughout the anal canal on rectal examination.

Laboratory studies: Hemoglobin was 12 gm. per cent, red blood cell count 4.26 million/ cubic ml., white blood cell count 8,950 with 65 per cent mature polymorphonuclears, 11 per cent bands, 18 per cent lymphocytes, and 6 per cent monocytes. Except for toxic granulations in many neutrophils, the smear was normal. Two urine specimens were both negative, except for trace of albumin and 2-8 white blood cells per high power field. Nonprotein nitrogen, fasting blood sugar, albumin, globulin, uric acid, cholesterol, prothrombin time, calcium and phosphorus were normal. Stool was one plus for occult blood, negative for ova and parasites, and stool culture was negative for tuberculosis, typhoid, paratyphoid and shigella organisms. Blood culture was negative. Serial agglutination tests for typhoid, paratyphoid, brucella, shigella shiga, flexner and sonnei, as well as antibody to proteus OX 19, were negative.

Electrocardiogram revealed only sinus tachycardia; a chest roentgenogram was negative. A barium enema study was reported as demonstrating "irregularity in the pelvic colon, with the mucosal pattern of the transverse and descending colon showing marked mucosal dis-

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tortion and small circular shadows which probably represent ulcerative colitis of the polypoid type. However, a primary condition of multiple polyposis of the colon has to be considered." A barium meal study showed no pathology of the upper gastrointestinal tract or small bowel.

Sigmoidoscopy I week after admission disclosed a reddish edematous appearance of the rectum with a few small ulcerations of the upper rectum; the general appearance was felt to be that of ulcerative colitis. No polyps were seen. Repeat sigmoidoscopy 2 weeks later was essentially the same. No biopsy was taken.

Course in hospital: The patient was given sulfasuxidine and penicillin, a high vitamin bland diet, antispasmodics and several blood transfusions. She gradually improved, became afebrile, and gained 5 or 6 pounds. At one point, 4 plus bilateral pedal edema developed. At this time, her serum albumin was found to have dropped to 2.9 gm. per cent. The edema spontaneously cleared, and she was discharged much improved on April 25, 1945.

Second Admission (January 10-February 5, 1946). The patient had been completely asymptomatic with one formed stool daily until October, 1945, at which time the stools became looser and she had 8 to 9 bowel movements a day. In November, 1945, there had been one episode of a bloody stool, and there had been a 14 pound weight loss during the 3 months prior to admission. For the 3 weeks prior to admission, there had been intermittent subcutaneous nodules on the arms and legs, absent on admission, and bluish discolorations around the knees. One knee had been painful, but not swollen, 2 weeks prior to admission. An ulcerated nodule on the left arm had been present for the past few days, increasing considerably in size. No investigation of the nodule had been made.

Physical examination was negative except for a temperature of 101° F., marked rectal tenderness, and a 1 cm. ulcerated nodule on the left forearm, as well as several tender discolored nodules on the skin of the extensor surfaces of both forearms. The left knee was held in slight flexion, and was painful on active or passive extension. No swelling was noted.

Barium enema and sigmoidoscopy examinations were the same as on the first admission. The hemoglobin, 8.5 gm. per cent on admission, rose to 12 gm. per cent on transfusions and supportive therapy. Her appetite was very good, and her fever gradually subsided. The nodule on her forearm was not biopsied, and she was

discharged much improved.

Third Admission (May 4-May 19, 1951). The patient did well on no other treatment than a low roughage diet, with 1-2 bowel movements a day, and only one episode of rectal bleeding in 1948, which stopped spontaneously. She was delivered of a healthy baby in November, 1946. There had been a 6 pound weight loss during the 6 months prior to this latest admission, with, however, no significant symptoms. This admission was prompted by 3 episodes of rectal bleeding within the prior 24 hours.

Physical examination was again negative except for diffuse mild abdominal tenderness, most severe in the left lower quadrant. Laboratory examination showed a hemoglobin of 10.5 gm. per cent, a white blood cell count of 10,300 with 80 per cent polymorphonuclears, 17 per cent lymphocytes, 1 per cent basophils and 2 per cent monocytes. She was given codein, sedation and, because of a low grade fever, several antibiotics, which were shortly discontinued. She was discharged improved on a short course of ACTH.

Fourth Admission (November 12-November 15, 1958). The patient's health improved considerably, and she was in excellent condition with only occasional short bouts of diarrhea. In January, 1952, she gave birth to a second child with no complications. She remained on a regular diet with no medication. However, one month prior to this admission, she noted a 1 day episode of blood-tinged stools. On the day prior to admission, she had had 4 painless bright red bowel movements. For the 6 weeks prior to admission, there had been some migratory arthralgia of the right first metacarpophalangeal joint of her hand, left elbow, and right knee.

Physical examination this time revealed an enlarged submaxillary lymph node, but was otherwise negative.

Laboratory studies were essentially unchanged, except for 2 plus albuminuria. Stool was strongly positive for occult blood. She remained afebrile, had no further bleeding while in the hospital, and refused to consider surgery for her chronic polyposis.

Final Admission (February 15-February 24, 1960). The patient gradually went downhill. During the last 2 years of life, she noted masses occurring in her neck when she menstruated. During the 2 months prior to the last admission, there occurred small, transient, exquisitely tender erythematous nodules in the skin of her legs. These were 1-2 cm. in size, and were diag-

nosed by a dermatologist as erythema nodosum. For the week prior to admission, her gums were swollen and tender, there were blood streaks in her sputum and nasal mucus, her face became swollen, and she was febrile, becoming very weak. She was placed on triamcinolone I week prior to admission, with no marked benefit. There had been blood in her stools for the past 7 months.

On physical examination, she was febrile and tachypneic, but in no acute distress. There were several very tender 0.5–1.5 cm. subcutaneous nodules on her legs and face, and ecchymotic areas on both legs. Her face was swollen, and there was clotted blood in her right nostril. There were enlarged bilateral anterior cervical lymph nodes and marked sternal tenderness.

Laboratory studies showed a hematocrit of 30 per cent. Her white blood cell count was 128,000/cubic mm. with the smear presenting "a monotony of abnormal forms believed to be myeloblasts and monoblasts...." Platelets were very diminished on smear and the platelet count was 10,000/cubic mm. There was mild microscopic hematuria.

A bone marrow aspiration was reported as typical of monocytic leukemia, acute form. She was placed on 6-mercaptopurine with little benefit. Cramps and diarrhea developed and, on the last day of life, there was nuchal rigidity and coma.

Autopsy Report. Permission for autopsy was limited to examination of the abdomen. The body was that of a well-developed, well nourished white female. There were multiple ecchymotic lesions on the anterior abdominal wall and multiple ulcerations of the gingivae and lips. No skin nodules were found.

Significant findings in the abdomen were as follows: The periaortic lymph nodes were slightly prominent and firm and, on cut section, were moist with a grayish white appearance. The liver weighed 1,750 gm. and was slightly enlarged. The only gross abnormalities were acute congestion and a solitary, well-circumscribed, firm nodule within the parenchyma of the right lobe. This was 3 cm. in diameter and whitish gray in appearance. The spleen weighed 475 gm. and was soft, pale red, and appeared to contain an infiltrative process. The esophagus was not examined; the stomach and small intestine were grossly normal. Examination of the colon, however (Fig. 1), showed numerous polyps throughout its entire length down to, but not including, the rectum. Most of the polyps were in the transverse colon. They were



Fig. 1. Gross specimen of a segment of patient's colon demonstrating numerous polyps, many of which are pedunculated.

very small, most having a diameter of 0.2 to 0.3 cm. Many of them were pedunculated, with stalks often 2 cm. in length. There was no gross evidence of malignancy. The only ulcerations found in the colon were 2 in the cecum, I cm. in diameter, that penetrated to the muscularis. Several hemorrhagic areas, denuded of mucosa, were seen in the rectum. In the mesentery adjacent to the cecum and ascending colon were multiple enlarged firm lymph nodes, hemorrhagic or whitish gray on cut section. The vertebral marrow was very pale red. The ovaries were replaced by two 3 cm. diameter cysts containing dark brown, thick liquid material. There was a uterine fibromyoma.

Microscopic examination of the autopsy material revealed infiltrates of tumor cells in the lymph nodes, bone marrow, liver, spleen, adrenal capsule (but not parenchyma), pancreatic interstitium and parenchyma, myometrium, kidneys, urinary bladder, uterus and colon. In the latter organ, multiple sections of the polypoid structures and the colon wall showed similar tumors, which had almost completely replaced the normal mucosa in the polypoid areas. It appeared that the tumor had pushed

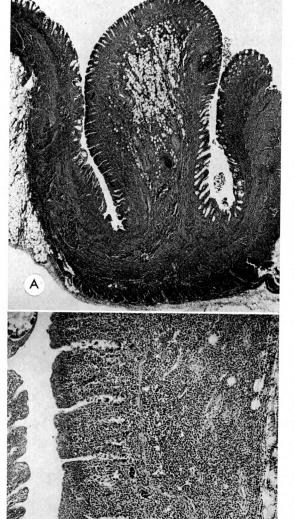


Fig. 2. (A) Photomicrograph of a typical polyp from Figure 1 (magnified 10×). (B) Section of the same polyp (magnified 60×) showing a diffuse infiltrate of round cells throughout the mucosa and submucosa. The muscularis was also invaded in many polyps.

up the mucosa in these areas, as these were neither adenomatous nor mucosal polyps (Fig. 2, A and B). Furthermore, there was no evidence of underlying inflammatory disease of

the colon such as would be seen in ulcerative colitis. One polyp was felt microscopically to be a carcinoid tumor, with no evidence of invasion of the stalk. A section of an ulcerated cecal area revealed absent mucosa in the area where the tumor cells had invaded the entire wall. The tumor cells (Fig. 3) occurred in sheets and the nuclei, of moderate size, showed considerable pleomorphism. The nuclei were ovoid, with some of them indented. Most of the nuclei were vesicular, with finely dispersed chromatin and scant amounts of eosinophilic cytoplasm in the cells. Occasional mitotic figures were seen. A reticulum cell stain showed the tumor stroma to be composed of a loose network of reticulum fibers.

The primary anatomic diagnosis was reticulum cell sarcoma involving all the viscera examined, with polypoid lesions in the colon apparently due to infiltration of tumor.

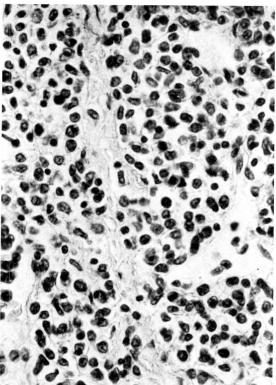


Fig. 3. Enlargement of a portion of Figure 2B (magnified 500×) showing reticulum cells. These have ovoid pleomorphic nuclei, some of which are indented. There is finely dispersed nuclear chromatin and scant eosinophilic cytoplasm in the cells. A reticulum stain revealed a loose network of reticulum fibers in the stroma.

### DISCUSSION

One must decide whether this was truly a pure case of malignant lymphoma, or originally "nonspecific ulcerative colitis," or multiple polyposis with later development of lymphoma. That ulcerative colitis and lymphoma coexist has been demonstrated several times. Cornes, Smith, and Southwood2 feel that from the present rarity of case reports of malignant lymphoma occurring with ulcerative colitis, one cannot determine whether the correlation is more than a fortuitous one. That an ipso facto relationship may be present, however, they note in the repeated episodes of lymphoid hyperplasia seen in the quiescent phase of ulcerative colitis, which may conceivably lead to the development of malignant lymphoma. Rankin and Chumley6 further bring up the fact that a large amount of lymphoid tissue is exposed to infection, chronic irritation, and toxemia in ulcerative colitis, possibly predisposing to malignant degeneration. But they, too, do not attempt to state a statistic significance in the occurrence of the two diseases in the same individual. Warren,14 however, feels that a correlation does exist.

Cornes et al.<sup>2</sup> note that in the healing phase of ulcerative colitis there are dense collections of lymphocytes with some plasma cells in the lamina propria and superficial submucosa. This may be misdiagnosed as lymphosarcoma by the inexperienced observer. This was not the case in the present report, in which the type of cell plus the deep extent of invasion leave no doubt as to its malignancy.

We believe that this was a case of malignant lymphoma from the start for the following reasons:

1. The roentgenographic picture never changed.

- 2. Of the numerous polyps examined, all contained lymphoma (with the exception of one carcinoid). One would have to assume preferential attraction of the tumor cells to all the polyps, which in the light of experience seems unlikely.
- 3. The colonic mucosa showed no evidence of chronic inflammation as seen in

ulcerative colitis. Furthermore, the polyps were not pseudopolypi of normal or granulation tissue between which the mucosa was destroyed, as in ulcerative colitis, but apparent elevation of the mucosa by masses of tumor cells, as described by the prosector. This latter point is, in addition, against the primary diagnosis of multiple polyposis with independent development of lymphoma.

To place this unusual disease in its true perspective, one must consider first the aspect of the long term survival and, second, the unusual location and form assumed by the lymphoma.

As for the first consideration, Rosenberg et al., in a review of 1,269 patients with malignant lymphoma, found a median survival from clinical onset of 26.4 months, considerably less than our patient, who had what is considered the form of lymphoma with the worst prognosis (reticulum cell sarcoma).

Concerning the second aspect, Rosenberg et al.<sup>10</sup> found that in their large series the first manifestation of the disease was in the gastrointestinal tract in only 4.6 per cent, with only 0.16 per cent presenting as colon and 0.39 per cent as rectal lesions. Other investigators have also found lesions localized to the colon and rectum to be very uncommon.<sup>1–5,11–13</sup>

The form taken by the disease is particularly noteworthy; for this woman exhibited not only the bloody diarrhea and roent-genographic picture of ulcerative colitis, but also arthralgias and erythema nodo-sum, both of which are well recognized entities in ulcerative colitis. This suggests that allergic manifestations may be secondary to the disturbance in colonic integrity rather than part of the primary disturbance.

The only other case somewhat similar to ours in the English medical literature of the past 34 years was reported by Rogers, concerning a 54 year old man with symptoms of abdominal pain and a small left groin mass, whose entire colon, including the rectum, was covered with countless sessile and pedunculated polypi shown to

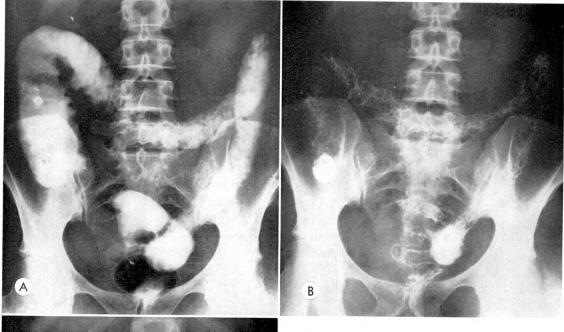




Fig. 4. (A) Barium enema study of patient taken in 1954. Unfortunately, earlier roentgenograms, which showed the same findings, are not available. On this roentgenogram, in which the colon is filled with barium, note the lack of foreshortening of the colon which one would expect to see with long standing ulcerative colitis with pseudopolypi formation. However, there is apparent rigidity and scalloping of the mucosa between the numerous polyps, as is commonly seen in lymphoma. (B) Postevacuation roentgenogram taken as part of the same study. The polyps are again seen, extending into, but not apparently below, the sigmoid colon. Note the ulcerating cecal lesion described at autopsy. (C) Post evacuation roentgenogram from a repeat study done on patient in 1959. Note the same appearance of the colon and the lack of foreshortening, despite presence of the disease for at least 14 years.

be reticulum cell sarcoma on biopsy. He lived for less than 2 years and exhibited none of the other stigmata that our patient had. Another case was presented in the French literature, in which the patient's entire colon showed a polypoid picture, with rectal biopsy revealing lymphoma. However, he also had hepatosplenomegaly and hemolytic anemia; and the stomach and

duodenum soon developed an abnormal appearance.

There is little reference in the English literature to the fact that malignant lymphoma may mimic ulcerative colitis. Cornes et al.<sup>2</sup> mention the fact and Wolf and Marshak<sup>16</sup> thoroughly describe the entity. When the lesions are visible via the sigmoidoscope, the true diagnosis may some-

Fig. 5. Postevacuation roentgenogram of a patient with proved chronic nonspecific ulcerative colitis with pseudopolypi formation. Although the mucosa shows scalloping and rigidity as in Figure 4, A, B and C, there is also decided foreshortening of the colon, not seen in lymphoma or congenital polyposis.

times be arrived at by the fact that the mucosal surface may be thrown into relief resembling the convolutions of the brain. <sup>15,16</sup> Even when appearing grossly normal, biopsy of the colon may give the diagnosis. Unfortunately, our patient never had a biopsy.

Nevertheless, the roentgenologic differential diagnosis of ulcerative colitis with pseudopolypoid changes, malignant lymphoma with polypi formation limited to the colon, and multiple adenomatous polyposis coli can be made or at least strongly suspected in many cases (Fig. 4, A, B and C; 5; and 6, A and B). Ulcerative colitis will



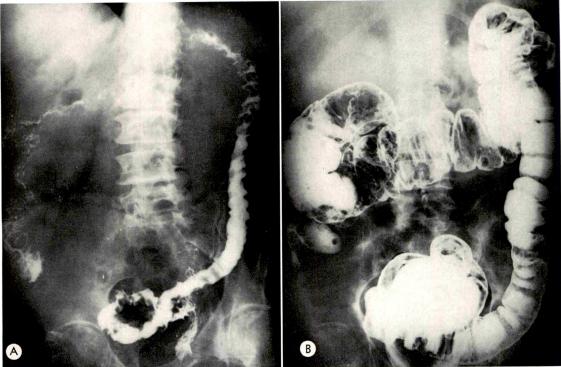


Fig. 6. (A) Postevacuation roentgenogram of a patient with proved multiple adenomatous polyps of the colon. There is no foreshortening of the colon. (B) Filled barium enema study of the same patient. The colon appears normal apart from the polyps. This fact tends to distinguish multiple polyposis from lymphoma of the colon.

show not only "polyps" on roentgenograms, but shortening of the colon as well, due to the chronic inflammation and scarring of the bowel (Fig. 5). Polypoid lymphoma and multiple polyposis coli are more difficult to differentiate; but the former may be suspected if the bowel appears persistently rigid on barium enema study, with rigidity and perhaps scalloping of the mucosal pattern between the polyps, indicative of lymphomatous infiltrate; whereas the mucosa between the polyps in the latter (Fig. 6, A and B) is pliable and of normal configuration.

This case has more than curiosity value, since surgical cures of gastrointestinal lymphomas have been documented. Although the patient in the present report did remarkably well for a long time, the fact remains that were earlier recognition of her disease possible, total colectomy might have cured her. Routine colonic biopsy in cases of suspected colitis, as is now practiced by our Department of Gastroenterology, might have afforded an early diagnosis.

# SUMMARY

- 1. A case is reported that is considered to represent malignant lymphoma of over 15 years' duration, masquerading clinically as nonspecific ulcerative colitis in that it was apparently originally precipitated by emotional stress and manifested bloody diarrhea, arthralgia, and erythema nodosum; as well as a roentgenographic picture of colonic pseudopolypi.
- 2. The literature concerning the occurrence of such a case is reviewed.
- 3. Means of distinguishing among ulcerative colitis with pseudopolypi, malignant lymphoma with formation of lymphomatous polypi, and multiple adenomatous polypi of the colon are discussed.
- 4. The importance of biopsying any diseased colonic mucosa, even in an apparently classic case of nonspecific ulcerative colitis, is stressed.

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# EXTRINSIC LESIONS AFFECTING THE TRANSVERSE COLON

By K. H. KENT, M.D. LYNWOOD, CALIFORNIA

THE accuracy of diagnosing a colon lesion correctly is high (80 per cent or better according to Allcock<sup>1</sup>). The failures consist basically of errors of omission or commission. Among the former, carcinoma of the cecum heads the list, among the latter differentiation between inflammatory and neoplastic disease and between an intrinsic and extrinsic process provides the greatest source of mistakes.

There have been several papers dealing with extrinsic involvement of the large bowel simulating primary lesion. 3,5,6,8,10 A general review is given by Pendergrass, and Marshak discusses the subject as regards the rectosigmoid. This paper concerns 6 selected cases showing deformity of the transverse colon from extrinsic disease suggesting primary carcinoma. Some of the diagnostic aspects peculiar to this location will be discussed. In 50 per cent of the group, the roentgenographic findings were interpreted as representing primary malignancy, whereas in the remainder this disease at least had to be considered.

# MATERIAL

This series consists of 4 white females between 29 and 61 years of age and 2 white males 48 and 63 years old, respectively. The final diagnoses were as follows:

- I. Cholecystitis with stones; fistula formation between the dome of the gallbladder and the right colon (Case I, Fig. I, A and B).
- 2. Stricture of the mid-transverse colon, secondary to fibrous adhesions (Case II, Fig. 2, Â-D).
- 3. Anterior gastroenterostomy bound by adhesions to transverse colon (Case III, Fig. 3, A and B).
- 4. Hemorrhagic pancreatitis involving the right transverse colon (Case IV, Fig. 4, A and B).

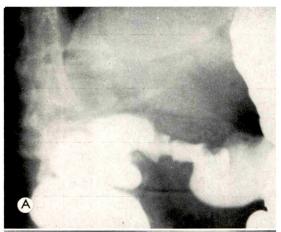




Fig. 1. Case I. M.R., white male, 63 years old. One week history of diarrhea and passage of bright red blood in the stools, 3 to 4 times daily. Final diagnosis: cholecystitis with stones and fistula between gallbladder and colon. (A) Annular constriction of transverse colon near hepatic flexure measuring 1 inch in length. Note apparent shelving defect; also faint outline of calcified gallbladder above. (B) Postevacuation roentgenogram shows localized area of mucosal irregularity. There is no retention in the ascending colon.

- 5. Carcinoma of the tail of the pancreas invading the left transverse colon (Case v, Fig. 5, A and B).
- 6. Carcinoma of the stomach invading the left transverse colon (Case vi, Fig. 6, A and B).

Table I

COMPARISON BETWEEN ROENTGEN AND PATHOLOGIC DIAGNOSIS

Patient	Roentgen Diagnosis	Pathologic Diagnosis	
Case I M.R. Male, 63	Carcinoma of hepatic flexure	Cholecystitis with stones; fistula between gallbladder and hepatic flexure	
Case II B.T. Female, 40	Ulcerating lesion of the mid-transverse collon, possibly malignant	Adhesive band with mucosal ulceration	
Case III E.G. Female, 61	Carcinoma of hepatic flexure	Adhesions	
Case IV A.H. Male, 48	Carcinoma of transverse colon	Hemorrhagic pancreatitis extending into right mesocolon	
Case v B.F. Female, 29	Carcinoma of splenic flexure, possibly extrinsic invasion	Carcinoma of tail of pancreas	
Case vi B.B. Female, 49	Carcinoma of left transverse colon, probably secondary invasion	Carcinoma of stomach invading colon	

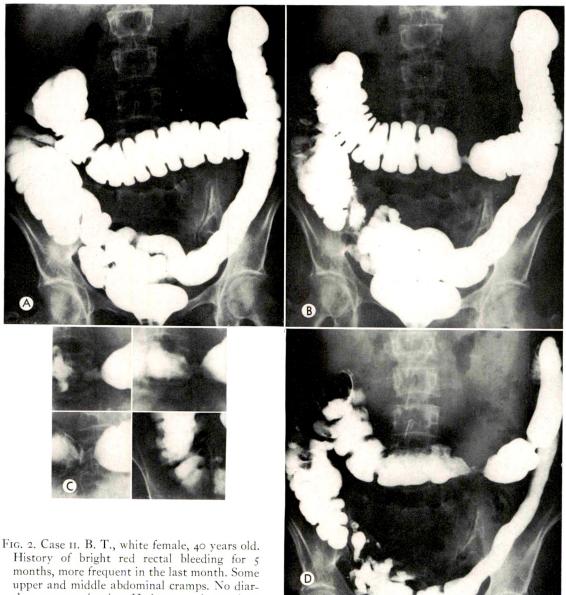
All patients had signs and symptoms referable to the gastrointestinal tract, some suggestive of colon pathology such as diarrhea or constipation, cramps and passage of blood. Only in Case vi was there a known diagnosis of primary gastric malignancy which eventually extended to the colon. Another patient (Case III) had had a previous adenocarcinoma of the rectum, but the transverse colon deformity proved not to be metastatic. Two thirds of the extrinsic lesions were benign. A comparison between the roentgen impression and the final pathologic diagnosis is summarized in Table 1. Brief historical data are supplied with each legend.

# DISCUSSION

While the diagnostic approach to extrinsic involvement is similar in all parts of the large bowel, the topography of organs neighboring on the transverse colon creates unique problems of its own. Diseases originating in the liver, gallbladder, stomach and pancreas can extend to involve this region

of the colon. In 5 out of the 6 cases, these organs were the seat of the primary disease.

A review of the literature revealed that Fisher and Brown<sup>3</sup> have described implants from a stomach carcinoma simulating a colon lesion. Melnick and Rosenholtz<sup>5</sup> report breast metastases to the colon, the appearance of which suggested ulcerative colitis. Conversely, the differential diagnosis of segmental ulcerative colitis simulating neoplasm is discussed by Branch and Sledge.<sup>2</sup> In a recent case report, Rockoff and Tuddenham8 describe an adherent gallbladder simulating an intrinsic lesion on the right side of the colon. A comprehensive study by Wigh and duV. Tapley<sup>10</sup> on metastatic lesions to the large intestine unfolds some rather interesting features. They find that the route of extension is either direct. embolic (lymphatic or vascular) or by peritoneal seeding. They state that the type of lesion produced by direct extension will simulate most closely a primary carcinoma. Early in their experience a roentgen diagnosis of inflammatory disease was usually



rhea nor constipation. Had surgery in previous

year for lysis of adhesions. Final diagnosis: adhesive band with mucosal ulceration. (A) Normal colon one year before admission. (B) One year later. Localized narrowing,  $\frac{1}{2}$  inch long, in left half of transverse colon with small niche on superior border. No definite mucosal destruction. (C) Ulcer is well seen on compression spot roentgenograms. (D) Postevacuation roentgenogram shows persistence of lesion. Emptying incomplete. No dilatation proximal to constriction.

offered but later on metastases were identified correctly. These authors also indicate that in annular and concentric metastases the typical shelving aspect of a primary carcinoma is replaced by tapered or conical extremities. While this observation is helpful, it is certainly not pathognomonic of

either primary or secondary malignancy. Nor is the length of the involved segment an absolute criterion. A long lesion is likely to be metastatic, but primary carcinomas measuring up to 8 inches have been reported. On the other hand, intact mucosa would rule against a primary cancer. Wigh

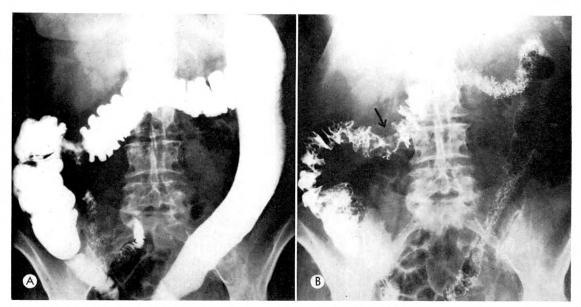


Fig. 3. Case III. E. G., white female, 61 years old. In 1955 had subtotal gastrectomy for duodenal ulcer and lysis of adhesions (previous cholecystectomy and appendectomy). In 1958 had adenocarcinoma of rectum with anterior resection and end to end anastomosis. Eight months later developed abdominal cramps, constipation, nausea and vomiting. Final diagnosis: anterior gastroenterostomy adherent to transverse colon. (A) Localized constriction in right half of transverse colon measuring I inch in length. Mucosal alteration. (B) Polypoid mucosal changes. Cancellation of normal haustral pattern. No retention in ascending colon.

and duV. Tapley found 20 out of 30 metastatic lesions to have a normal mucosa. Mucosal destruction may result both from inflammatory and neoplastic processes and does not aid in separating intrinsic pathology from outside involvement.

This series includes 2 cases of primary disease of the pancreas affecting the transverse colon, one benign and one malignant (Case IV and V). Pancreatitis advancing into the hepatic flexure and simulating carcinoma is particularly interesting (Case IV). The "cut-off" sign, first defined by Stuart,9 is clearly demonstrated on the barium enema study (Fig. 4A) (but not on the plain roentgenogram as originally described). It is due to an extension of the pancreatic inflammatory process into the mesocolon with resultant collapse of a contiguous localized segment of transverse colon. Gas on both sides of the collapsed segment gives it the "cut-off" appearance. Stuart's attention was called to this sign by the observation of a surgical colleague, Price, who commented on operative find-

ings in 2 cases of pancreatitis similar to the one illustrated herein. Price describes a "cellulitis spreading from the edematous head of the pancreas between the layers of the transverse mesocolon to reach the mesocolic border just to the left of the hepatic flexure." Although the roentgen study of Case IV (Fig. 4B) demonstrated retention of barium in the ascending colon and a narrowed segment with apparent mucosal destruction suggestive of a primary lesion, the surgeon reported that the collapsed segment was merely the result of encroaching edema. The roentgenologic analysis pointed to carcinoma with the exception of two observations: the considerable length of the lesion and the absence of shelving. Neither one of these two, as previously stated, will hold up under scrutiny as absolutely reliable. The second case of a primary pancreatic lesion (Case v) was a carcinoma of the tail of the pancreas (Fig. 5, A and B). Its appearance was more conventional. While a primary tumor could not be ruled out, at least the length of the

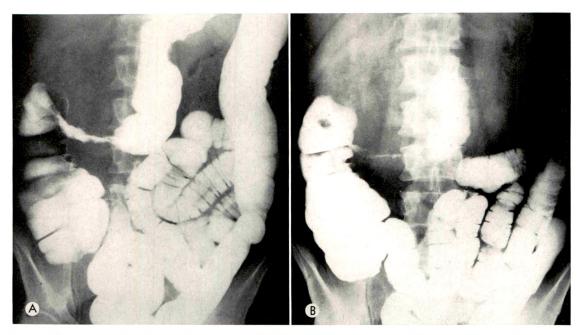


Fig. 4. Case IV. A. H., white male, 48 years old. Weight loss, anorexia and frequent vomiting for I year. Sudden onset of severe epigastric and right upper quadrant pain, nausea and vomiting; fever, leukocytosis and albuminuria. Subtotal gastrectomy for duodenal ulcer 3 years previously. Final diagnosis: hemorrhagic pancreatitis (huge mass of hemorrhage and pancreatic fat necrosis on the right side). (A) Sharply narrowed transverse colon segment near hepatic flexure  $2\frac{3}{4}$  inches in length. Shaggy margins, tapering ends. Apparent mucosal destruction. (B) Postevacuation roentgenogram. Although this is a benign lesion there is retention in ascending colon. The edematous infiltration is sufficient to cause obstruction.

colon segment strongly suggested metastatic invasion. A similar reasoning was applicable to Case vI where a large tumor of the stomach encircled the splenic flexure (Fig. 6, A and B).

Case I is an example of adherence of a diseased gallbladder and penetration into the colon wall in the pre-fistula stage mimicking a primary lesion (Fig. 1, A and B). Here a short annular constricted segment with some shelving of the margins and obliteration of the normal mucosa was demonstrated. It is, however, noteworthy that, while there was a resistance to the retrograde barium flow which led to the detection of the pathologic process, there was absolutely no sign of delay in emptying. The finding of retention proximal to the lesion on the postevacuation roentgenogram is a frequent and important clue in the diagnosis of primary malignancy.

The dilemma in cases of extrinsic pathology due to adhesions and bands is well

exemplified by Case III (adherent gastroenterostomy). Even in retrospect, the diagnosis of a primary or possibly metastatic malignancy is favored in view of a known antecedent rectal cancer. In Case II (stricture with ulceration) malignancy was thought to be unlikely but because of the ulcer crater a primary process seemed indicated. The clinical history in such cases can be both helpful and misleading. The subject is ably described by Overton et al.6 They report 3 instances of benign extrinsic lesions preoperatively diagnosed as carcinoma, i.e., 2 cases of adherent epiploic appendices and I of a completely circular and unattached band. They further discuss unusual causes of deformities of the colon among which are diaphragmatic hernia, spasm, residuals of previous inflammatory processes as well as retroperitoneal and intraperitoneal masses. The symptomatology in their material was suggestive of primary bowel malignancy: weight loss, change in

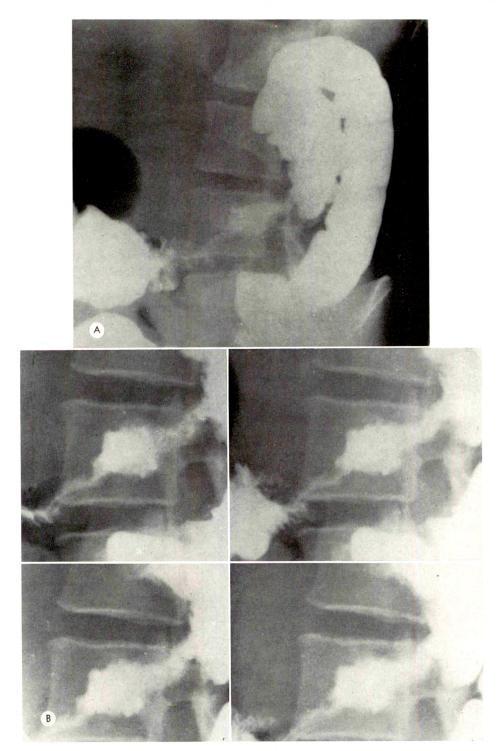


Fig. 5. Case v. B. F., white female, 29 years old. Four month history of mass in left upper abdomen, anorexia and weight loss. At first operation it was thought to be carcinoma of the splenic flexure. Second surgery disclosed tumor in tail of pancreas invading the stomach and the transverse colon. (A) Extensive lesion, 3 inches long in left half of transverse colon near splenic flexure. Segmental fixation and mucosal destruction. (B) Spot roentgenograms of same lesion.



Fig. 6. Case vi. B. B., white female, 49 years old. Gastric resection for cancer of stomach 2 years prior to admission. Well for about 1 year; then began to complain of weight loss, progressive weakness and anorexia. Final diagnosis: carcinoma of stomach invading colon. (A) Large constricting lesion in left transverse colon near splenic flexure measuring 5 inches in length. Complete obliteration of normal mucosa with sharp demarcation and segmental fixation. Proximal spasm. (B) Postevacuation roentgenogram. Note retention in ascending colon.

bowel habit, cramps, abdominal pain and rectal bleeding. Repeated roentgen studies demonstrated constant defects and partial obstruction.

There is little difference in basic pathology in extrinsic lesions affecting the transverse colon or the sigmoid colon except topography. After enumerating the various entities, Marshak<sup>4</sup> arrives at a simplified etiologic classification: extrinsic pressure due to (I) inflammatory reaction (and adhesions usually are the result of inflammation) and (2) tumor masses (benign or malignant). The 6 cases in this series easily fall into these categories.

In summary, it can be stated that the transverse colon may be affected by pathologic processes of its neighboring organs and by adhesions. The purpose of this paper is to emphasize that these extrinsic lesions may simulate primary carcinoma. Whenever the roentgen aspects do not

quite fit into the conventional pattern of cancer of the colon, secondary involvement should be suspected. A perusal of the literature and an analysis of the present material fail to vield absolute criteria of differential diagnosis. However, helpful hints can be gleaned from the foregoing discussion and from related papers. No diagnosis should be attempted without adequate history, especially of previous surgical intervention. A lesion exceeding 2 inches in length is more likely to be extrinsic. Absence of barium retention proximal to the lesion on the postevacuation roentgenogram favors nonmalignant invasion. Intact mucosa and lack of a shelving defect militate against primary carcinoma. On the other hand, mucosal destruction is seen in both extrinsic and intrinsic lesions. The difficulties will multiply when one attempts to differentiate between benign and malignant secondary processes. At this level, the patient's history may be

of aid. It is significant that 4 out of 6 cases in the present series had benign lesions.

#### SUMMARY AND CONCLUSIONS

- 1. Six instances of lesions secondarily affecting the transverse colon are discussed.
- 2. The etiology includes inflammatory adhesions and benign and malignant processes extending from the gallbladder, stomach and pancreas.
- 3. The roentgen diagnosis favored cancer of the transverse colon, either primary or metastatic. The possibility of benign etiology was considered seriously in one case only.
- 4. The literature is reviewed and helpful suggestions are presented by which to differentiate extrinsic from intrinsic lesions.

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## A NEW TECHNIQUE FOR THE ROENTGENOLOGIC EXAMINATION OF THE COLON\*

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IT IS estimated that the number of roentgenologic examinations of the colon is of the order of several million per year in the United States alone. This, in itself, is proof of the great importance of this diagnostic procedure to the practice of medicine.

No fundamental improvement in the method of conducting the roentgenologic study of the large bowel occurred until 1923 when Fischer<sup>2</sup> evolved the double or air contrast technique. Subsequently, Weber<sup>25</sup> and Gershon-Cohen and Shay<sup>3</sup> introduced the procedure to this country and certain refinements have since been made. However, the basic steps involved in the conduct of the double contrast examination remain generally unchanged.

With the recent development of a disposable enema kit containing barium and permitting a closed system, <sup>16</sup> a major modification in the execution of a roent-genologic study of the colon became possible. Significant advantages over the customary ways of examining the large bowel can now be realized for both the standard examination and the air contrast method. Furthermore, special additional benefits accrue to both the patient and the examiner when this technique is selected.

The added usefulness of the air or double contrast examination over the older, standard procedure requires little documentation today. Filling the bowel with the barium mixture under fluoroscopy and taking roentgenograms before and after the patient has evacuated constitute the older, standard method. Most radiologists now employ the double contrast method as the more informative examination. Its capability in the detection of polypoid lesions not only is unsurpassed, but the technique

also holds special advantages in the diagnosis of most other conditions that may affect the colon either directly or indirectly. 19,22,27

The accuracy of air contrast studies in the detection of intraluminal defects has been proved by Welin,<sup>26</sup> who discovered these lesions in 12 per cent of 1,608 patients. Sixty per cent of the tumors he found were less than 5 mm. in diameter.

All current methods for the application of the air contrast technique, however, have certain important disadvantages.

- 1. The examination may cause prolonged distention of the large and sometimes the small bowel as well, with the result that very distressing cramps and abdominal discomfort ensue. These symptoms may continue for several hours or until absorption or expulsion of the air has taken place.
- 2. A potentially serious problem, which seems to be largely unavoidable, is fecal contamination of the enema equipment, including the enema can, the air insufflation device and particularly the tubing.12,15,16,21,22 The effective sterilization of each of these pieces of apparatus is difficult, time consuming, and usually impractical. Consequently, it is customarily not done. The possibility of the transmission of enteric pathogens and the spreading of diseases, such as typhoid fever, shigellosis, infectious hepatitis, amebiasis, poliomyelitis, and infestations with certain species of worms or parasites from patient to patient is a very real one. 12,15,16,21 Further investigation of the possibility of spreading disease from patient to patient by means of this widely used diagnostic technique is certainly indicated and is now being undertaken.13

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Cancer cells have been recovered from washings of mucus from the large bowel in many cases of ulcerative carcinoma.<sup>5</sup> These cells, therefore, could conceivably be transmitted from patient to patient by means of the customary barium enema equipment although the possibility of any serious consequence ensuing would appear to be extremely remoteor impossible as judged by the present knowledge of the transmission of cancer.

- 3. The air contrast technique is often time consuming because it is necessary to wait until the patient leaves the roent-genographic table, evacuates, and then returns from the toilet. Often the time involved in these steps can escape the radiologist's full control.
- 4. Evacuation may be either inadequate or too complete. Furthermore, if the patient lingers in the toilet for too long a period, there is the added and serious disadvantage of flaking or drying of the barium on the mucosa, a circumstance which spoils double contrast visualization.
- 5. The patient may not be physically able to go to the toilet. Stretcher or bedridden cases necessitate the use of a bedpan. Many cannot evacuate readily. This is often the case when studies are done of patients with a colostomy opening.
- 6. There is sometimes an inability of the patient to retain either the enema mixture or the air, with resultant spillage of barium and feces on the roentgenographic table.
- 7. Reinsertion of the enema tip is required after the patient evacuates. An occasional patient expresses resentment at having to undergo this unpleasantness for what seems to him to be two more or less separate examinations.

All of these disadvantages have been generally recognized by radiologists. Templeton and Addington<sup>24</sup> proposed the use of a device producing drainage and suction of the barium, thus obviating the need of the patient leaving the roentgenographic table; Hodges<sup>4</sup> also suggested the use of a similar device. These devices, however, appear to be somewhat cumbersome. They are obviously difficult to sterilize and re-

portedly one is prone to clogging.<sup>24</sup> Moreton et al.14 and Stevenson22 advocated the use of a Y-shaped adapter in selected cases, viz., young patients and those unable to leave the roentgenographic table easily. This procedure would enable one to fill the colon with a limited amount of barium and air simultaneously, but no provision was made to evacuate the colon routinely by this means. Adequate evacuation and satisfactory filling therefore could not always be obtained. Similarly, Lusted and Miller<sup>10</sup> advised the use of the "pneumocolon bottle." However, this is not a truly closed system since in order to evacuate the colon it is necessary to break the connection with the rectal cannula.19 It seems doubtful that the positive pressure within the bottle, which is variable, would consistently prevent reflux of barium from the colon. It has been found that intrarectal water pressure may reach a value above 75 cm. of water during mass peristalsis. 15 As with the other devices mentioned above, sterilization of the entire system would seem to be necessary in order to avoid transmission of contaminants.

An inflated balloon on a catheter has been used as a means of retaining the tube in place in the rectum and to prevent spillage of barium and air. This is often ineffective, however, and some radiologists hesitate to employ the retention balloon because of instances of perforation of the rectum associated with its use.<sup>17,18</sup>

Aluminum bedpans<sup>28</sup> have also been suggested for the examination of the incontinent patient, but they interfere with the study since the patient cannot be turned easily during fluoroscopy and roent-genography, and also because any barium accumulating in the bedpan obscures the image of the colon.

## AUTHORS' TECHNIQUE

This new technique for the examination of the colon avoids most of the aforementioned disadvantages. The entire procedure depends upon the special disposable prepackaged barium enema kit recently de-

veloped<sup>16</sup> to provide a closed system.\* This kit is inexpensive, easy to use after a brief experience and a safe, single-stage examination may be accomplished with it. The following factors were considered and evaluated in the development of this new technique.

#### I. SELECTION OF A PROPER BARIUM MIXTURE

A comparative study was made of a number of different barium preparations. Considered particularly were the adequacy of the coating of the mucosa for double contrast examination, the adequacy of the flow rate through the tubing, the suitability for hand mixing as opposed to machine mixing, ready availability, and cost. It was found that "Raybar F"† fulfilled the above criteria. One pound of barium plus 1,500 cc. of water provided the most satisfactory mixture.

#### II. SELECTION OF THE GAS

In a search for a gas more satisfactory than air, it was found that carbon dioxide offered obvious advantages. Carbon dioxide is absorbed 150 times faster than the nitrogen of the air.7,8,11 Because of its great solubility and prompt chemical combination in the blood, carbon dioxide is much less likely to produce gas embolism than air,7,8,20 an eventuality which could conceivably occur in the presence of severe ulcerative and inflammatory conditions of the bowel. Carbon dioxide has been used extensively for tubal, intraperitoneal and presacral insufflation, although its use in the latter procedure has been abandoned by some because of its rapid absorption which in this particular study can be a drawback.1 Carbon dioxide is nontoxic, noninflammable, readily available and inexpensive. Following rapid intravenous injection of 7.5 cc. per kg. of carbon dioxide in dogs, there is a 5 to 10 volume per cent increase of the whole blood carbon dioxide

content.<sup>20</sup> However, this alteration is of extremely brief duration, reaching a maximum within 15 to 30 seconds and disappearing in 1 or 2 minutes. Carbon dioxide is readily eliminated by the lungs. If direct intravenous injections produce such small changes, it seems very unlikely to us that the use of carbon dioxide for double contrast study of the colon would significantly affect the pH of the blood or create a potential hazard except in most unique circumstances.

The use of carbon dioxide for colon insufflation is not new. Many of its advantages were clearly pointed out by Levene and Kaufman.<sup>8</sup> With their method of administration of the gas directly into the colon from the tank, prompt and precise control of the regulator on the tank in the darkened room during fluoroscopy may not always be easy.

Consideration of all these factors led to the employment of carbon dioxide instead of air in conjunction with the disposable enema kit. With the method that was finally devised, the amount of gas delivered to the colon could be strictly controlled by the examiner. In addition, the hazard of transmission of enteric pathogens by means of the commonly used insufflation devices is entirely eliminated.

## III. THE CONDUCT OF THE EXAMINATION

The disposable barium enema kit prepackaged with the barium sulfate (Fig. 1) is half filled by the addition of 1,500 cc. of tap water directly through the enema tip (Fig. 2) or by means of a funnel (Fig. 3). A thorough mixing of the water and barium is then carried out. An excellent mixture is readily obtained by kneading, pressing, and squeezing the bag for less than 1 minute.

The plastic bag is then elevated and carbon dioxide is introduced from the tank through the enema tip (Fig. 4). Approximately I liter of the gas will distend the bag sufficiently. The carbon dioxide, of course, rises to the top when the bag is in this position, above the barium and water mixture (Fig. 5). If desired, air can be

<sup>\*</sup> The disposable prepackaged barium enema kit can be obtained from the E-Z Em Co., 130 Maple Street, Great Neck, Long Island, New York.

<sup>† &</sup>quot;Raybar F"—product of Bell-Craig Co., New York, New York.

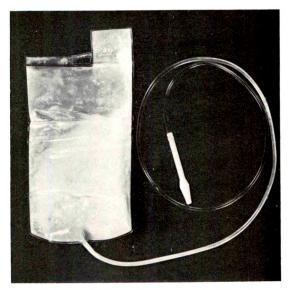


Fig. 1. The disposable prepackaged barium enema kit.

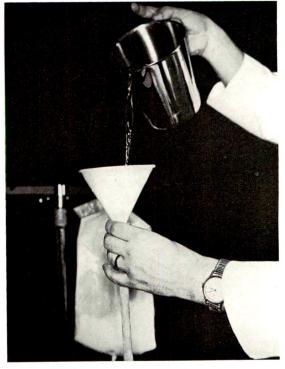


Fig. 3. The kit may also be filled by adding a premeasured amount of water through a funnel.



Fig. 2. The bag is half filled by the addition of tap water through the enema tip.

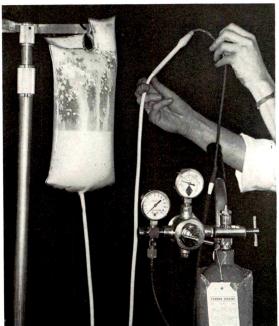


Fig. 4. Carbon dioxide is introduced via the enema tip.

introduced in the same fashion by means of a standard insufflation device. The bag could also be filled simultaneously with water and air by the use of a Y-shaped adaptor placed between the enema tip and the faucet. Regardless of the method used in preparing the kit, it is a relatively simple procedure which can be easily performed by nonprofessional personnel outside of the roentgenographic room. The enema is then ready for immediate use. However, it can be stored for a day or so before use without deterioration of the contents.

The kit has incorporated within the bag a filter tube which prevents any particles or clumps of barium from entering the tubing. We regard this device as an important feature of this disposable enema kit. The barium flows readily through the tubing as the bag is elevated (Fig. 6). Effective control of the flow can also be obtained by manual pressure on the bag. If one prefers to use an exceptionally thick

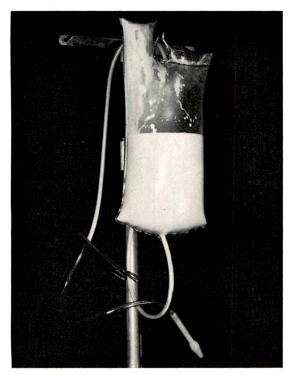
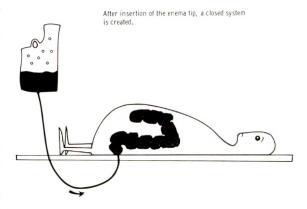


Fig. 5. The kit half filled with tap water and distended with carbon dioxide.



Flow rate controlled by:

Degree of elevation of the bag

Gentle manual pressure on the bag

Pressure cuff (when a thicker mixture is preferred).
The incorporated filter prevents passage of clumps into the tubing.

Fig. 6. The conduct of the single stage closed system double contrast examination. This diagram illustrates the filling of the colon with barium.

and viscous barium mixture, an adequate rate of flow can be obtained either by means of a blood pressure cuff (thigh type) wrapped around the bag or by using a large size pressure infusor.

An added feature of major significance of this closed system is that by lowering the bag sufficiently the bulk of the enema may be siphoned off with immediate relief on the part of the patient of any overdistention of the colon or cramps (Fig. 7). The material can then be reintroduced at will (Fig. 7). The avoidance of spillage of barium mixture and feces on the examining table is thus assured. If this maneuver were done with conventional equipment, instant and massive contamination of the entire system, including the can, would result and offensive odors would be created in the room.

The initial phase of the barium enema examination may be performed in the usual fashion with this equipment, and, at the completion of fluoroscopy and roentgenography, the patient may be allowed to visit the toilet. When he returns after evacuation for the double contrast part of the study, the carbon dioxide is easily introduced into the colon by simply inverting

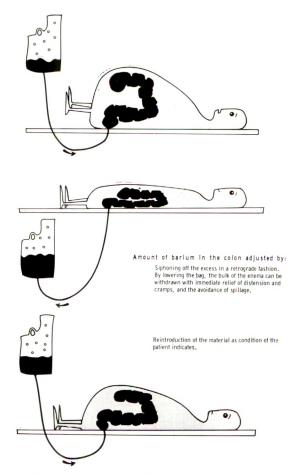


Fig. 7. These diagrams illustrate the adjustment of the amount of barium in the colon. In the lower diagram the patient is ready for roentgenography of the filled colon.

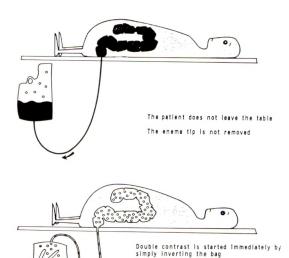
the bag and applying gentle manual pressure on the bag during fluoroscopic observation. Some degree of manual pressure is always required to start the flow, the pressure of the gas, by itself, being never sufficient to be dangerous.

However, an alternative and, as we now believe, a more satisfactory method can be employed. This will result in an improvement in the over-all quality of the examination together with a saving in time and a lessening of any discomfort to the patient. It has been determined that there is no need for the patient to leave the examining table to evacuate in the toilet. A one-stage examination may thus be obtained. The bowel of the patient can be evacuated

sufficiently by lowering the bag either with the patient supine or standing erect (Fig. 8). The effectiveness of this maneuver is readily checked by fluoroscopy and, if necessary, it can be repeated. Too little or too much elimination of the barium can thus be avoided. A blood pump apparatus could also be used to accomplish emptying of the colon. If one desires postevacuation roentgenograms, these are now obtained or a delayed roentgenogram taken within 30 to 45 minutes after the completion of the double contrast phase will also give a good mucosal pattern. Very little gas remains in the colon at this time due to rapid carbon dioxide absorption (Fig. 9, A and B). We find, however, as experience grows, that the usefulness of postevacuation roentgenograms seems to diminish. No longer are they taken routinely as was customary previously.

Carbon dioxide is next introduced into

Passive, controlled evacuation is effected by lowering the bag.



CO<sub>2</sub> is introduced into the colon by applying gentle pressure.

Amount and rate of flow are controlled by fluoroscopic observation.

Fig. 8. These diagrams illustrate the passive, controlled evacuation of the barium, effected by lowering the bag, and the immediate introduction of CO<sub>2</sub> for the double contrast, effected by inverting the bag and applying gentle pressure. The entire examination is performed in a single stage and the closed system is not broken.

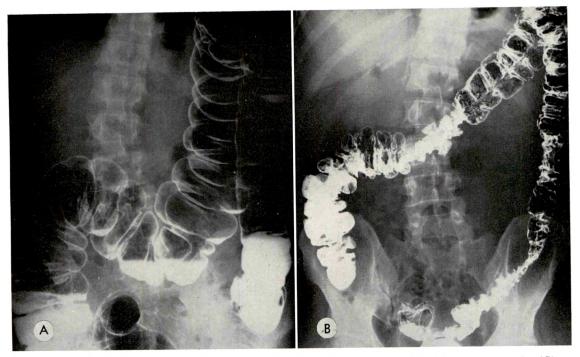


Fig. 9. (A) Roentgenogram of the colon immediately after completion of double contrast study. (B) Note almost complete absorption of the carbon dioxide 45 minutes later.

the colon by simply inverting the bag and applying gentle manual pressure on it under fluoroscopic control (Fig. 8). The need for reinsertion or exchange of the rectal tube, which is customary with the conventional procedure in double contrast examinations, is thereby eliminated. Time is saved by not having to wait until the patient more or less voluntarily returns from the toilet; by not interrupting the examination or delaying the gas insufflation, the cracking, peeling and fragmentation of the barium are eliminated and consequently a superior mucosal coating is usually obtained. Experience has convinced us that a major cause of failure to obtain good double contrast coating is the delay between evacuation of the bowel and the injection of the

The disposable kit has a special usefulness in cases in which the examination has to be interrupted before the colon is sufficiently filled due to the patient's inability to retain the enema. In these cases a good study can still be obtained and a significant



Fig. 10. Roentgenogram showing the diagnostic quality which is obtained with the new technique.

number of repeat examinations can be eliminated in the following manner. After withdrawing an amount of barium by lowering the position of the bag, just sufficient to relieve the patient's discomfort, gas is insufflated by inverting the bag and applying gentle manual pressure. This is done provided sufficient barium is left to produce a satisfactory double contrast study. If insufficient barium is left, then more can be slowly introduced, with small, intermittent withdrawals as the patient's reactions dictate. By this method of alternate introduction and withdrawal, enough barium can be retained to make a successful examination possible (Fig. 7).

After the introduction of carbon dioxide, the barium column may be advanced, if desired, by means of the pressure of the gas but chiefly by placing the patient in the right posterior oblique position. An excellent cecal delineation is usually afforded and excessive filling of the ileum can almost always be avoided.

## IV. SELECTION OF PATIENTS

There are virtually no contraindications to this new technique of roentgenologic examination of the colon. Patients who were formerly judged unsuitable for double contrast studies due to their clinical condition or inability to retain the barium were successfully examined with the new closed system, one stage technique. Good studies were also obtained as a rule in post colostomy patients, following controlled siphonage of the barium and careful introduction of the gas.

#### V. PREPARATION

The routine recommended preparation is 2 ounces of castor oil, light breakfast and cleansing water enemas in the morning before the examination. In special cases (usually repeat studies) a 2 day liquid, nonresidue diet as well as a daily dose of castor oil is recommended.

#### RESULTS

We have examined over 1,000 patients using this new method. The results have

been gratifying. The incidence of abdominal cramps was significantly reduced and there was no instance of discomfort lasting more than half an hour (Fig. 9, A and B). The total time required for the colon examination by the use of the one stage technique has been considerably shortened. A full study now rarely requires more than 20 minutes. It is estimated therefore that the time of examination has been reduced to approximately half of that of the previous double contrast technique. Spillage of barium rarely occurred and, when it did, it appeared to be due to the fact that the examiner was not fully aware that he could have prevented it by simply siphoning off the barium at the first signs of discomfort on the part of the patient.

In addition, the change towards an obviously more sanitary method of colonic examination was well received by the medical staff, patients and personnel. The hospital staff was reassured as to the elimination of the danger of cross infection, particularly in regard to certain categories of patients. Our fellow radiologists preferred the disposable kit and the new technique to the previous one, appreciating both the shortening of the study and the increased flexibility of the examination. The patients experienced a greater degree of security in terms of a more personalized and closely controlled examination.

The nonprofessional personnel welcomed the time saved in the preparation of the enema. The kit and tubing were prepackaged and were always ready for immediate use in either simple or double contrast studies. The administration of the enema was made easier since the shortened and simplified method of examination obviated reinsertion of the enema tip or exchange of the tubing. Finally, because the kits were disposable, washing, cleaning and sterilization of equipment were entirely eliminated.

The quality of the examinations was notably improved. These studies were almost invariably rated excellent or good (Fig. 10). There were a number of cases in which

previous barium enema studies were available so that the results of the old and the new techniques could be compared. In all instances, the new studies were of better or at least of comparable quality when compared with the previous one. This was attributed mainly to a uniform technique based on a constant and dependable barium mixture, controlled emptying of the colon, and avoidance of delays in introducing gas and taking the double contrast roentgenograms.

#### SUMMARY

A new method of examination of the colon is described employing a closed system, one stage technique, by means of a prepackaged, disposable barium enema kit. Careful selection of the barium mixture and the use of carbon dioxide contributed in an important way to the success of the method.

The following are the advantages of this new technique:

- 1. Prevention of transmission of enteric pathogens from patient to patient.
- 2. A closed system with avoidance of spillage of barium and feces and the creation of offensive odors.
- 3. One stage procedure obviating both the need of the patient to leave the roentgenographic table to go to the toilet and the reinsertion of the enema tip.
- 4. Evacuation controlled by the examiner.
- 5. Shortening of the time of the examination.
  - 6. Disposability of the enema apparatus.
- 7. Reduction of abdominal discomfort due to prolonged distention of both large and small bowel.
- 8. More comfortable and reassuring procedure for the patient.
- 9. Absence of any serious contraindications.
- 10. Labor saving and improved over-all efficiency.
  - II. Low cost.
- 12. Esthetically, a more satisfactory method of colon examination.

13. Generally improved quality of the roentgen studies diagnostically.

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# AN EVALUATION OF THE RADIOACTIVE FECAL FAT ANALYSIS\*

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THE use of radioisotope labeled fat and fatty acids has gained rather widespread recognition within the last few years as a means of evaluating the gastrointestinal system. At this institution we have employed the procedure of blood analysis as originally described by Baylin *et al.*<sup>1</sup> along with radioanalysis of the feces as described by Sanders *et al.*<sup>7</sup>

It is the purpose of this article to present the results of our experience with these tests over a period of 7 years.

#### METHODS AND MATERIALS

In this laboratory fecal radioanalysis is routinely carried out with all fat absorption studies, unless it is deemed not feasible.

The fat meal has consisted of either glyceroltrioleate emulsion<sup>1</sup> and capsules<sup>3</sup> or of oleic acid capsules.<sup>4</sup> These have been administered according to the methods described originally. Oleic acid studies are not included in this series for analysis.

The procedure performed basically has not varied significantly since its origin in 1954. 1.7 All of the feces is collected in individual containers over a period of 48 hours. There must be careful exclusion of all urine from the feces at the time of collection. Each individual collection is analyzed and the total radioactivity in the feces is determined. The percentage of the previously administered radioactivity which is present in the fecal material is then computed.

The results of the procedure have been classified according to the clinical diagnosis at the time of discharge from the hospital or at the time of the most recent notation on the chart. In many cases the diagnosis was confirmed at surgery or autopsy. No at-

tempt was made in this study to distinguish between proven and nonproven diagnoses.

#### RESULTS

Table I shows the total number of patients examined and the total number of tests performed. It also shows whether the blood and fecal radioanalyses were normal or abnormal. The upper limit of normal for the fecal excretion value was statistically determined to be 3 per cent (P=.05) of the administered radioactivity excreted in urine free feces in 48 hours. If the sum of the percentage of radioactivity in the blood of samples taken at 4, 5, and 6 hours after the beginning of the test reached 23.6 per cent

Table I

A COMPARISON OF BLOOD AND FECAL RADIOANALYSIS
AFTER ORAL ADMINISTRATION OF LABELED
GLYCEROLTRIOLEATE TEST MEAL
AUGUST, 1954 TO AUGUST, 1961\*

No. of Patients Examined	1,652	
No. of Fecal Fat Tests on Patients	1,466	
No. of Blood Analyses on		
Patients	1,946	
	Total No.	
Simultaneous Blood and Fecal		
Analyses	1,421	100
Agreement between Blood and		
Fecal Analyses	1,004	71
Disagreement between Blood and Fecal Analyses	417	29
Blood analysis abnormal, fecal analysis normal	145	10
Fecal analysis abnormal, blood analysis normal	272	19

<sup>\* 133</sup> normal controls were not included in this table.

<sup>\*</sup> From the Department of Radiology, Duke University Medical Center, Durham, North Carolina. Supported in part by NIH grant A-836, Division of Arthritis and Metabolism.

TABLE II

comparison of blood and fecal values after  $I^{131}$  labeled glyceroltrioleate test meal

Normal values as per cent of orally administered radioactivity

Blood—sum of the 4 hr. +5 hr. +6 hr. samples  $\geq 24\%$ Fecal—sum of the 48 hr. excretion  $\leq 3\%$ 

	of	Per Cent of Total
Normal Blood Value—Normal		
Fecal Value	638	45
Normal Blood Value—Abnor-		
mal Fecal Value	272	19
Abnormal Blood Value—Nor-		
mal Fecal Value	145	IO
Abnormal Blood Value—Ab-		
normal Fecal Value	366	26
Total No. of Tests	1,421	100

(lower limit of normal P=.05) or more of the administered dose, then the blood level was considered to fall within normal limits. It may be noted that the two tests agreed in 71 per cent of the cases and disagreed in 29 per cent.

Table II gives a comparison of the blood and fecal analyses as to agreement and disagreement. The fecal value was abnormal in 19 per cent of the cases where the blood was normal and in 10 per cent where the blood was abnormal.

Table III lists the principal types of cases in which fecal analysis was carried out. It also shows the average fecal radioiodine recovery and the range in each of these types as well as the percentage of abnormal tests. The large number of patients in the miscellaneous group had no further analyses carried out in the present study.

In Table IV the percentage of patients presenting with abnormal tests is given. The discrepancy between the number of patients having fecal analyses and those having blood analyses is due to the fact that some patients had multiple fecal analyses particularly when the test was used as a means of evaluating therapy in cases with gastric resection and sprue.

#### DISCUSSION

A large percentage of patients had both fecal analyses and blood analyses (Table 1). Some cases showed a normal blood analysis and an abnormal fecal value. A review of the clinical record of many of these revealed that there were minor gastrointestinal abnormalities in digestion or absorption which could account for the elevated fecal recovery. These results suggest that fecal analysis is a more sensitive indicator, thus enabling one to detect minor disturbances of the gastrointestinal system. These observations agree with our findings in a previous work in which we reported a group of patients undergoing irradiation of the abdomen. Many presented an abnormal fecal recovery with normal blood levels, suggesting at that time that the fecal analysis was a more sensitive test for determining malabsorption or maldigestion than the blood analysis.

Another group of patients showed abnormal blood values with normal fecal levels; however, a review of the laboratory data in most instances disclosed an incomplete fecal collection, thus explaining the disagreement in these cases.

The average fecal recoveries for each clinical classification (Table III) indicate that these fall into 2 distinct groups: Group I with averages ranging from 2–6 per cent, and Group II averaging from IO–I9 per cent. The latter group of cases are without exception those in which this test procedure is thought to have definite diagnostic capabilities. Group I with the lower average value is composed of those conditions in which the glyceroltrioleate absorption test is thought to be of limited value.

There is a tendency to apply the criteria of chemical fat balance recovery as the upper limit of normal for the radioactive glyceroltrioleate absorption study. This would place samples of up to 7 per cent within normal limits. This application of upper limits of normal from chemical fat recovery studies to radioactive glyceroltrioleate recovery is not justifiable. Statistically, the radioactive glyceroltrioleate

TABLE III
ANALYSIS OF TEST DATA

Type of Case	No. of Patients	Total No. of Fecal Tests	Observed Fecal Range (per cent)	Average Fecal Recovery (per cent)	No. of Abnormal Tests	Per Cent of Abnormal Fecal Tests	Upper Limit of Normal (P=.05)
Normal Controls	133	133	0-6.1	I.2			2.7%
Gastric Resection	268	317	0-88.4	15.6	211	67	
Vagotomy Vagotomy and	4	4	0-4.7	2.3	2	50	
Resection Vagotomy and Gas-	19	28	0-49.5	13.5	20	72	
troenterostomy Pyloric Channel and	35	35	0-52.3	15.0	28	80	
Bulbar Ulcers	63	60	0-45	5.I	22	37	
Regional Enteritis	34	38	0-77.4	14.3	25	66	
Scleroderma	13	12	0-20.2	5 · 4	6	50	
Whipple's Disease	7	16	0-44	10.6	9	55	
Sprue	25	36	0-95	19.4	26	72	
Irritable Colon Diverticulosis of	15	13	0-50	2.I	3	23	
Colon	7	8	o- 3.8	1.5	2	25	
Ulcerative Colitis	18	15	0-14.2	3.6	6	40	
Cholecystectomy	27	16	0-5.4	2.I	3	19	
Cholelithiasis	23	19	0-18.7	3.8	7	37	
Cirrhosis	28	17	0-31.1	5.8	8	47	
Hepatitis Cystic Fibrosis of	23	18	0-26.8	5.6	12	67	
the Pancreas	25	23	0-77.9	13.5	16	69	
Pancreatitis Carcinoma of	170	119	0-79.5	13.3	72	61	
Pancreas	112	70	0-93.7	16.2	36	5 I	
Diabetes Functional	52	34	0-60.6	4.2	10	29	
Disturbance	172	154	0-16.3	2.1	23	15	
Miscellaneous Total (not including	510	416			281	67	
controls)	1,652	1,466			827	56	

study shows an upper limit of normal of fecal recovery of 2.7 per cent (P=.05). We therefore classify any fecal recovery above this level (2.7 per cent) as being abnormal.

#### GASTRIC ABNORMALITIES

A large number of the cases in which both the blood and fecal tests were abnormal were those of gastric resection. The reason for this is not completely known, however the possibility of the meal completely "out running" the pancreatic enzyme due to the location of the anastomosis with respect to the common duct entrance into the small bowel must be considered. In the work by James *et al.*<sup>5</sup> in which a glyceroltrioleate test meal was placed via a tube into the first portion of the jejunum, thus bypassing the ampulla, abnormal blood and fecal values were produced in normal subjects. This would seem to support the above concept.

Another possible explanation might be the disturbance of fibers of the vagus nerve during the process of performing the gastric resection, therefore removing some of the stimulation from the central nervous system to the viscera. Some suggestion of the effect of the vagus nerve on the ability of

TABLE IV
ANALYSIS OF PATIENT DATA

Group Diagnosis	No. of Patients Having Fecal Tests	No. of Patients with Abnormal Fecal Tests	Per Cent of Patients with Abnormal Fecal Tests
Normal Controls	133	_	
Gastric Resection	234	7	5
Vagotomy		146	62
Vagotomy and Resection	4 14	2	50
Vagotomy and Gastroenterostomy	27	12	86
Pyloric Channel and Bulbar Ulcers		2 I	78
Regional Enteritis	53	19	36
Sclerodema	32	18	56
Whipple's Disease	9	3	33
Sprue	7	5	7 I
rritable Colon	25	17	68
Diverticulosis of Colon	13	3	23
Ilcerative Colitis	6	2	33
Cholecystectomy	15	6	40
Cholelithiasis	21	7	37
Cirrhosis	19	7	37
Iepatitis	14	8	57
Systic Fibrosis of the Pancreas	17	10	59
ancreatitis	22	16	73
arcinoma of Pancreas	81	41	51
Diabetes	64	37	58
unctional Disturbance	34	10	29
liscellaneous	141	11	8
riscenaneous	344	141	
T-4-1			4 I
Total	1,329	408	31

the digestive tract to handle fats might be obtained by observing the difference between the percentage of patients presenting abnormal fecal tests in gastric resection without vagotomy as compared to those of gastric resection with vagotomy; *i.e.*, 62 per cent as compared to 86 per cent. This is shown in Table IV. The vagotomy group is too small to be of significance; however, the abnormal values of the vagotomy-gastroenterostomy group might be explained on the basis of one or both of the above reasons.

It was shown in this study that 19 per cent of those patients having both blood and fecal analyses had normal blood tests with abnormal fecal recoveries. A large percentage of this group were gastric resection cases. In these instances we believe the fecal analysis is the true indicator of the

ability to digest and absorb fat. The shortened transit time may explain the difference between the normal blood studies as compared to the abnormal fecal tests. With a rapid transit time, the blood levels which are seen only during the fourth through the sixth hour may very well fall within the lower limits of normal, as the material would still be in the process of being absorbed throughout this period. If one followed the blood analyses further, it is probable that the levels would drop off faster than in the true normal case. Consequently, the material which rapidly went through the small bowel without being absorbed would appear in the feces and show an abnormal test. Since in most of the gastric resection cases the blood levels fall in the lower limit of normal, usually between 8 and 9 per cent for all three hours, the

fecal test seems to be a more sensitive indicator of the true condition of the gastrointestinal system.

#### PYLORIC CHANNEL AND BULBAR ULCERS

Approximately 36 per cent of the patients with pyloric channel and bulbar ulcers showed abnormal fecal fat levels. The average of these fecal levels was rather low, being 5.1 per cent (Table III). The possibility exists that an associated pancreatitis involving the head of the pancreas might be present in some of these cases producing a decrease in pancreatic secretion. Another possibility might be an alteration in the transit time through the small bowel.

#### REGIONAL ENTERITIS

Of the 32 patients with regional enteritis, 56 per cent had abnormal tests. The extent and possibly the location of involvement determine the presence or absence of measureable steatorrhea. In these cases with abnormal triolein, the oleic acid absorption test was abnormal, indicating malabsorption and not maldigestion.

#### SCLERODERMA

Only about one-third of the cases of scleroderma showed abnormal results. The average of the fecal recovery was in the Group I range, described above, indicating the test to be of limited value in diagnosing this disease. The presence of steatorrhea is probably evidence of the severity of the disease.

#### WHIPPLE'S DISEASE

A large percentage of the patients with Whipple's disease had abnormal fecal analyses. The average of the fecal recoveries was rather high. We believe this test to be of definite value in the diagnosis of Whipple's disease. The oleic acid absorption also was depressed in these cases.

#### SPRUE

There was a high percentage of patients with sprue who had abnormal triolein absorption studies. The average fecal recovery was high, thereby placing this dis-

ease in Group II in which the test is of definite diagnostic value. The large number of tests in this classification—i.e., 36 in comparison to the total number of 25 patients—may be accounted for on the basis of its use in evaluating therapeutic response. Some of these patients with a normal response who did not show abnormal fecal tests were those in remission. All active sprue cases showed abnormal fecal recoveries. We have seen cases in which the presence of an abnormal test preceded the advent of clinical symptoms and signs of sprue.

#### IRRITABLE COLON

This group consists of patients with intermittent diarrhea for which no organic cause was demonstrated. It is of interest to note that 23 per cent of these patients had abnormal fecal studies. The average fecal recovery was low (2.1 per cent). On several occasions these patients have eventually presented with other gastrointestinal abnormalities. This might have been the reason for the earlier abnormal study.

#### DIVERTICULOSIS

In this small series the average of the fecal recovery was very low. Two of the 6 cases had abnormal fecal recoveries. We have no logical explanation for this other than simply a chance occurrence. We do not feel that this series is large enough to warrant any conclusions.

#### ULCERATIVE COLITIS

Forty per cent of this group of patients had abnormal fecal studies. Possible explanations for these could be small bowel involvement, rapid transit time, and bleeding into the colon.

#### LIVER AND BILIARY DISEASE

It has been previously reported that the elimination of the bile from the gastrointestinal tract decreases only slightly the ability to digest glyceroltrioleate in this test preparation. A slight depression of the blood levels in dogs with common duct ligations has been observed; however, this is

only to the lower level of normal. Marked depression of the blood level has not been found. This would correspond with the slight elevation noted in the average fecal fat recovery in cases of liver and biliary disease. We feel that the procedure is of limited aid in diagnosing these diseases and, therefore, categorize them in Group I.

### CYSTIC FIBROSIS OF THE PANCREAS

A large number of patients showing abnormal fecal tests and high average fecal recoveries was expected in the presence of pancreatic disease. The degree of abnormality in these cases undoubtedly varies with the degree of involvement of the pancreas. The oleic acid study is frequently abnormal, indicative of disease other than that limited to pancreatic secretions.

#### PANCREATITIS

The degree of abnormality which patients with pancreatitis show appears to be determined by the amount of destruction of the pancreas that has taken place. A rather large portion of the pancreas can be removed and the blood test will remain within normal limits. This has been demonstrated in the dog by Frazer *et al.*<sup>2</sup> A high average fecal recovery was noted in these cases.

#### CARCINOMA OF THE PANCREAS

An abnormal test in carcinoma of the pancreas is dependent upon the location of the tumor and the extent of the involvement. A tumor located in the tail or the body of the pancreas may not produce changes unless there is rather widespread destruction of the gland. A tumor in the head of the pancreas and obstructing the duct will lead to a grossly abnormal test.

We have studied several patients with abdominal and back pain in which all tests performed were normal except the radioactive fat absorption test. Surgical exploration revealed the presence of a neoplastic process in the head of the pancreas.

The glyceroltrioleate absorption test has been of value in the differential diagnosis of jaundice. A markedly abnormal test in the presence of jaundice would be an indication of obstruction involving the pancreatic duct as well as the common duct. This would suggest the possibility of carcinoma of the pancreas as well as stricture or stone obstructing the ampulla. If, however, the fat absorption study is normal or very near normal, then the diagnosis of carcinoma of the pancreas is not likely.

#### DIABETES

A relatively low incidence of diabetic patients with abnormal fecal test was found. Frequently the exocrine function of the pancreas is not disturbed in diabetes mellitus and normal tests under these conditions can be expected.

#### FUNCTIONAL DISTURBANCE

The percentage of patients in the functional disturbance group having abnormal fecal recovery, using 3 per cent (P=.05) as the upper limit of normal, was II per cent. This upper limit of 3 per cent, when applied to the normal population, would classify 5 per cent as being abnormal. Therefore, there is an unexplained 6 per cent of so-called functional disturbances in which abnormal fecal recovery is observed. We have encountered cases initially classified as having functional disturbance with abnormal fecal recovery, but which on closer analysis or at a later date were found to have organic disease related to the gastrointestinal tract. Consequently, we feel that those patients classified as having functional disturbance with abnormal fecal studies should be followed very closely.

#### MISCELLANEOUS

The large number of cases grouped under miscellaneous represent those conditions in which the number of any one group was not sufficiently large to warrant analysis at this time.

#### SUMMARY AND CONCLUSION

An analysis of results obtained with the use of I<sup>131</sup> labeled glyceroltrioleate over a period of 65 months are presented. The following conclusions are made:

- 1. The fecal analysis procedure is a simple, reliable and inexpensive method of evaluating gastrointestinal function and can be carried out with ordinary thyroid counting equipment.
- 2. It is desirable where possible to do both blood and fecal analyses.
- 3. The fecal analysis, when proper collection is obtained, is a more sensitive and more accurate indicator of disease than blood analysis.
- 4. The average fecal recoveries in diseases of the gastrointestinal tract may be divided into two distinct groups: those in which the test is of limited value (average fecal recovery 2–6 per cent) and those in which the test is of definite value (average fecal recovery 10–19 per cent). The conditions in which the test is of definite value are (a) gastric resection, (b) vagotomy and resection, (c) vagotomy and gastroenterostomy, (d) regional enteritis, (e) Whipple's disease, (f) sprue, (g) cystic fibrosis, (h) pancreatitis, and (i) carcinoma of the pancreas.

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# MUCOSAL IMPRINTS OF THE PROXIMAL ALIMENTARY CANAL USING A THERMOPLASTIC TUBE\*

By GALEN B. COOK, M.D., and ALEXANDER R. MARGULIS, M.D. st. louis, missouri

ISEASES of the human gastrointestinal tract are difficult to diagnose when inaccessible to direct vision or when too small to be observed roentgenographically. Attempting to resolve these difficulties, a technique was devised for making mucosal impressions of the human colon using a silicone foam moulage that gives a precise reproduction of the mucosal surface and permits locating small abnormalities so that their anatomic topography and adherent surface cells can be studied.1 This diagnostic method has now been used to examine the sigmoid colons of more than 200 persons. Assessing the results, we judge the test safe and effective. We conclude that the principle of mucosal imprinting is sufficiently informative that it might be applied advantageously to other portions of the body—particularly the proximal alimentary canal.

A means for making imprints of the esophagus and small intestine has been devised. In this presentation its development and experimental use in dogs and human autopsy specimens will be reported.

### DEVELOPMENT OF THE THERMO-PLASTIC TUBE

It is unreasonable to believe that a bulky mold—like that used in the colon—could be placed in either the esophagus, a portion of the stomach, or the small intestine without frequent complications. To be safely retrieved from the upper gastrointestinal tract, the mold must pass the narrowings of the pharynx, the gastric cardia, and the pylorus without causing injury; that is, it must be hollow and sufficiently elastic to

collapse. Such characteristics are found in a thin rubber tube and this might serve to take imprints if its walls would deform to mucosal detail and retain the deformation when subsequently collapsed. This could be accomplished if the rubber were coated with a polymer that was convertible, reversibly and at will, from the stable state to the amorphous state. Thermoplastics perform this way to temperature changes and should be useful for taking mucosal imprints in man if a thermoplastic could be found that was (1) adhesive to rubber, (2) impressible just above body temperature, (3) supple, but of stable configuration, at lesser temperatures, (4) nontoxic, (5) radiopaque, (6) nondigestible, and (7) agreeable in odor and texture. In addition, this thermoplastic should be sufficiently tacky to entrap exfoliated cells, yet not so tacky as to adhere to the intestinal mucosa or to itself. Furthermore, this plastic must be adaptable to manufacture, unchanged by storage, and inexpensive to be practical.

#### COMPOSITION

A resin, polyvinyl butyral (Butvar D-510)<sup>a</sup> can be blended with a plasticizer, alkyl aryl phosphate (Santicizer 141)<sup>b</sup> to produce a thermoplastic that softens sufficiently at 45° C. to record imprints and entrap exfoliated cells; when cooled it retains the imprint and the cells (Fig. 1). This plastic adheres to rubber and can be made into a stable, smooth film which is almost odorless. It is resistant to succus entericus and is compatible with barium sulfate. Its

A Shawinigan Resins Corporation, Springfield, Massachusetts.
 Monsanto Chemical Company, St. Louis, Missouri.

<sup>\*</sup> From the Department of Surgery and The Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri.

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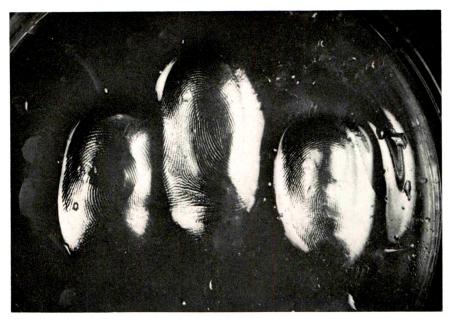


Fig. 1. Fingerprints made on a film of plasticized polyvinyl butyral at 45° C. The capability of the material to record fine detail is apparent.

ingredients have passed extensive toxicity tests and have U. S. Federal Drug Administration approval for packaging food.

This resin-plasticizer is soluble in a mixture of ethanol and xylene. These solvents convert the dry, powdered resin and the oily plasticizer to a clear syrupy liquid which, when applied slowly, releases the solvent uniformly. Because the evaporation rates of ethanol and xylene are different, they are mixed in a ratio of 230:70 so that each is freed completely at the same time.

In order to make inspection of the imprints easier, titanium oxide is added to render the film white and opaque. In the amounts and manner used here titanium oxide has no apparent toxicity.

#### PREPARATION

For these studies, one-half inch, radiopaque Penrose drains were coated with the following mixture:

polyvinyl butyral (Butvar D-510)	100	gm.
alkyl aryl phosphate (Santicizer 141)	125	gm.
ethanol	270	ml.
xylene	80	ml.
titanium oxide		gm.

<sup>°</sup> Davol Rubber Company, Providence, Rhode Island.

This formulation is stirred at room temperature to give a liquid that resembles common house paint in color-density and viscosity.

Using an air-pressure paint spray, the material was applied over the surface of rotating Penrose drains to produce a smooth, uniform film, I mm. thick (Fig. 2A). Rotation was continued for 6 hours to assure complete evaporation of all solvents and then the coated Penrose tube was dusted lightly with silica aerogel (Santocel FR-C) to reduce tack at ambient temperature. Finally, the thermoplastic tube was removed from the rotational rod and the distal end was tied securely with two threads to seal the tube and embed a  $2\times0.5\times0.5$  cm. bar of Alnico metal. The proximal end was connected to two 12 Fr. Levine tubes that were attached to a Semco Aquaflow pump (model 222), making the thermoplastic tube part of a closedcircuit water circulation system (Fig. 2B). This pump gives a steady flow of 570 ml. per minute and is constructed so that the

d Binks Manufacturing Company, Chicago, Illinois.
 e Monsanto Chemical Company, St. Louis, Missouri.

f Semco Sales and Service Company, Inglewood, California.



Fig. 2. (A) Application of the thermoplastic coating to a rotating Penrose drain. (B) Aquaflow pump used to fill, soften, and stabilize the thermoplastic tube. Cannister on left contains ice water; cannister on right has heating jacket and thermostat to maintain warm water at sufficient temperature elevation to deliver water into the tube at 45° C.

inflow can be changed instantly from warm (45° C.) to cold (4° C.).

#### APPLICATION

The tubes were filled with cold water to remove air and to maintain complete stability of the thermoplastic as they passed through the gastrointestinal tract at 37° C. To begin, the tubes were placed in the dogs' esophagi with a laryngoscope and were then slid to the stomach (Fig. 3). Further progression into the small intestine was aided with an electromagnet under fluoroscopic control. When located at the level of the

alimentary tract under study, the cold water was replaced with warm water and maintained at 45° C. 3 minutes. The imprint was thus made. Maintaining a constant tube volume, cold water was replaced in the tube to stabilize the impression. When this exchange was complete, the pump was stopped and the tube withdrawn and inspected. The tubes were stored in a refrigerator.

THE PREPARATION OF ANATOMIC DEFORMITIES IN THE JEJUNUM AND ESOPHAGUS

To determine the effectiveness of the thermoplastic tube for recording mucosal detail, celiotomies were made on dogs and deformities were constructed through enterostomies. The thermoplastic tube was then introduced into the area of abnormality and an imprint was made.

A "sessile lesion" was placed on the jejunum by implanting an upholstery tack from within the bowel wall. The head of

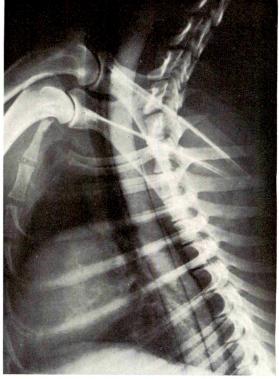


Fig. 3. Thoracic roentgenogram of a dog showing radiopaque thermoplastic tube within the esophagus.

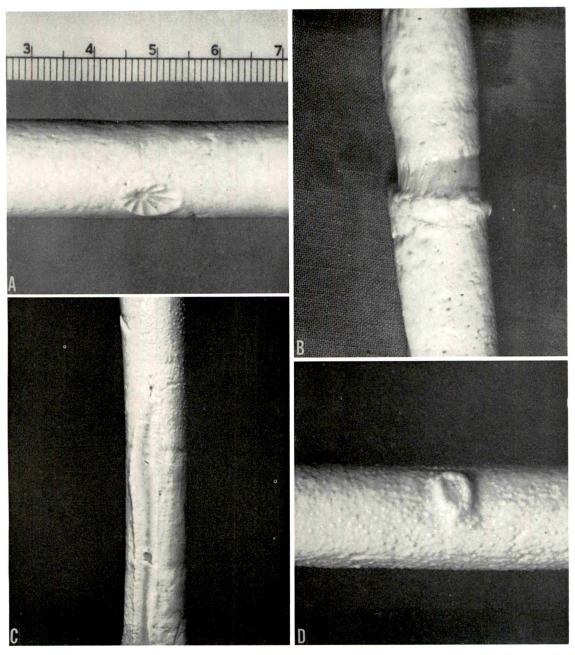
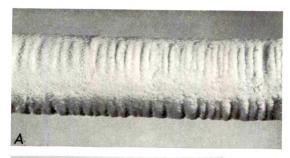


Fig. 4. Impressions of surgically-produced mucosal defects in dog jejunum made on thermoplastic tubes. The granular surfaces in the noninvolved areas are due to air bubbles in the plastic caused by imperfect spraying. (A) "Sessile lesion" (head of an upholstery tack); (B) jejunojejunal anastomosis; (C) "varix" (strand of rubber); and (D) ulcer.



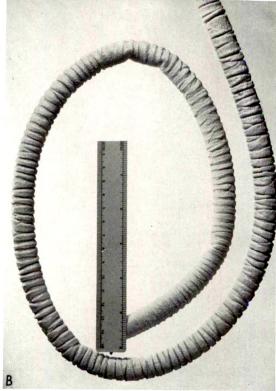


Fig. 5. (A) Thermoplastic tube imprint of the ascending colon of a rabbit. Note taeniae and haustral markings. (B) Thermoplastic tube imprint of human jejunal autopsy specimen.

this tack had an embossed pattern so that it resembled a 0.7 cm. sessile abnormality with definite surface characteristics as might be seen in an early carcinoma of the ampulla of Vater (Fig. 4A).

A jejunojejunal anastomosis was made and 6 weeks later an imprint was taken. At the time of imprinting, the anastomosis was fully healed with no evidence of obstruction (Fig.  $^{4}B$ ). A "varix" was produced by suturing an irregularly shaped strand of rubber longitudinally along the mucosal surface of the distal esophagus. This structure was made to resemble a human varix, although, admittedly, it was not as compressible as is the actual lesion in man (Fig. 4C).

An ulcer was produced on the jejunal mucosa by denuding a circle of mucosa 0.5 cm. in diameter (Fig. 4D).

Tissue specimens of the organs which came in contact with the thermoplastic tube were studied for histologic change and all intraperitoneal organs were inspected.

To supply further examples of the tubes' capabilities to record, an imprint was made in a resected specimen of the ascending colon of a rabbit (Fig. 5A) and in an autopsy specimen of human jejunum (Fig. 5B).

#### RESULTS

The ability of the thermoplastic tube to record minute detail is apparent. Each of the "lesions" was recorded with considerable accuracy and the examples of normal mucosa reproduced the anatomy as it actually appeared.

No trauma was caused by introducing or removing the tubes. No pathologic changes were found in the mucosa exposed to the plastic over the temperature range and time intervals used. No evidence of toxicity to organs outside of the alimentary tract was seen.

#### DISCUSSION

In dogs, it is impossible to perform this type of examination without general anesthesia. In man, we have found that the tube can be used painlessly with only topical anesthesia to the oropharynx. The results suggest that the thermoplastic tube is more tolerable and appreciably safer than an esophagoscope.

Our experience in placing the thermoplastic tube into the small intestine with an electromagnet is limited to dogs. From the clinical experience that has been recorded with the Avco electromagnet,<sup>2</sup> we are optimistic that these accomplishments can be transferred to man.

The tolerance of the mucosa to heat appears to be related directly to the duration of exposure. Brief exposures at 45° C. are safe.<sup>3</sup> To further increase the margin of safety during softening of the thermoplastic, the 45° C. temperature is now being maintained for 15 seconds instead of the original 3 minutes. There is no loss in the quality of the imprints.

The thermoplastic tube has not been designed as a replacement for barium examinations. Rather, it is intended to clarify the unusual or the occult process that cannot be fully understood by existing methods. Within these boundaries the thermoplastic tube promises to be a worthwhile adjunct, and, to date, our favorable experience in man confirms this belief.

Currently, studies are being made to appraise this technique for examinations of the stomach, uterine cavity and bronchus distal to the limits of a bronchoscope. In these instances the balloons are shaped to the contours of the organ studied.

As this technique becomes better developed, it is certain that the surface of the tubes may be made flawless using the

extrusion techniques of those skilled in plastic manufacture.

#### SUMMARY

A plastic-coated rubber tube has been developed for obtaining diagnostic imprints and recovering exfoliated cells from the mucosal surface of the proximal alimentary canal. The method for making the tube and the experiences attending its use in dogs are recorded.

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## PERIGASTRIC ADHESIONS\*

## THE "TRAPPED AIR" SIGN

By CHARLES E. SHOPFNER, M.D. OKLAHOMA CITY, OKLAHOMA

PERIGASTRIC adhesions may cause deformity and irregularity of the stomach which are difficult to distinguish from carcinoma. They were first described in 1948 by Jenkinson and Hamernik<sup>3</sup> and again by Jenkinson et al.4 in 1952. In 1961 Geffen and Feldman<sup>1</sup> discussed the etiology and incidence of 10 additional cases and the validity of diagnostic criteria to distinguish them from carcinoma. These criteria are those of Golden<sup>2</sup> and Kirklin<sup>5</sup> and indicate the presence of carcinoma with some degree of certainty, but benign conditions such as perigastric adhesions are indicated only in a negative way. Previous literature mentions no finding or sign which is specifically diagnostic of perigastric adhesions.

Such a sign was first observed in 1959 when a peculiar pocket of air was noted along the lesser curvature of the gastric antrum in a patient with a penetrating duodenal ulcer (Fig. 1). At surgery the trapping of air was found to be due to fixation and elevation of the antrum by dense perigastric adhesions.

Subsequently, this air trapping has been observed and evaluated in 57 patients, 20 of whom had surgical exploration. This phenomenon of air trapping has been called the "trapped air" sign, and has proven to be a reliable indication of perigastric adhesions. The intent of this paper is to discuss the causes and pathology of the adhesions and present the principle of the "trapped air" sign.

#### CAUSES

The principal disease found at operation was accepted as the cause of the adhesions in the 20 surgically explored patients (Table 1). In the other 37 cases which

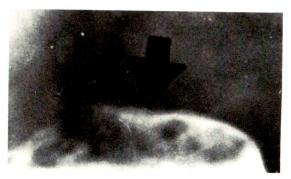


Fig. 1. First patient in whom the "trapped air" sign was seen. Air is trapped in the broad area of the fixed, elevated stomach wall.

showed the "trapped air" sign but did not have surgery, the causes were determined as accurately as possible by history (Table II).

There was some variation between the two groups, but the three main causes were peptic ulceration, gallbaldder disease and previous surgery. These three accounted for 65 per cent of the causes in the surgically proven group and for 92 per cent in the group where causes were determined by

TABLE I
CAUSES IN 20 CASES
(SURGICALLY PROVEN)

Cause	Cases	Per Cent of Cases
Duodenal Ulcer	5	25
Cholecystitis Cholecystectomy	3	15
Congenital	3	15
Pyloroplasty	2	10
Ventral Hernia	2	10
Pancreatitis	2	10
Trauma	2	10
Gastric Ulcer	I	5
Total	20	100

<sup>\*</sup> Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 2-5, 1962.

TABLE II
CAUSES IN 37 CASES
(BY HISTORY)

Cause	Cases	Per Cent of Cases
Duodenal Ulcer	9	24
Cholecystectomy	ΙI	30
Pyloroplasty with Hiatus		
Hernia Repair	11	30
Congenital	2	6
Pancreatitis	I	2
Gastric Ulcer	3	8
Total	37	100

history. In the 10 cases described by Geffen and Feldman, 9 were due to these three causes.

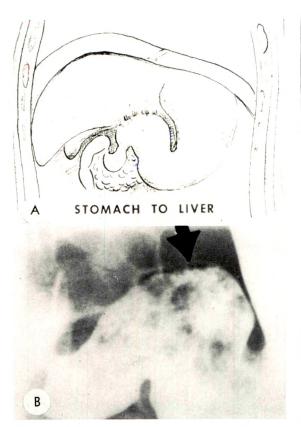


Fig. 2. (A) Sketch of surgical pathology. (B) Roentgen pathology. "Trapped air" is present. The "S" deformity is characteristic of stomach to liver adhesions. Note close correlation between roentgen and surgical pathology. The adhesions were due to cholecystitis.

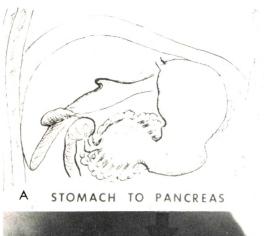




Fig. 3. Stomach to pancreas adhesions were usually secondary to duodenal ulcer or pancreatitis. (A) Sketch of surgical pathology. (B) Roentgen pathology. The adhesions cross the antrum to produce irregularity, and then pass on to body and tail of the pancreas, fixing and elevating the stomach wall which allows air to be trapped. Antral irregularity such as this should not be called "antritis" when a "trapped air" sign is present. The adhesions in this patient were due to pancreatitis.

### PATHOLOGY

The 20 operated on patients all showed perigastric adhesions along the lesser curvature of the antrum and lower body of the stomach. This is true not only because the cases selected showed the trapping of air in this location, but also because pathology that causes perigastric adhesions occurs almost exclusively at this site. The adhesions were grossly no different from adhesions that are found elsewhere in the abdomen. The stomach was uniformly bound to four organs: the gallbladder, pancreas, liver, and diaphragm. In most instances

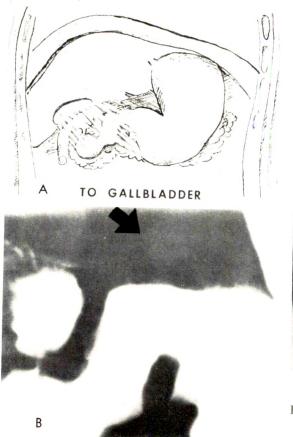
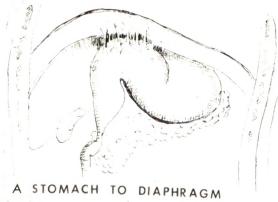


Fig. 4. (A) Sketch of surgical pathology. (B) Roentgen pathology. Adhesions fixing stomach to gall-bladder cause different type of deformity because of change in obliquity. The arrow points to "trapped air." The adhesions were due to cholecystectomy.

adhesions were present between the stomach and two or three of the other organs, but the major adhesions were usually attached primarily to one organ.

Correlation of the roentgen and surgical pathology showed that the adhesions produced deformity, irregularity, fixation, and elevation of the stomach wall. All cases were not clear-cut, but characteristically an "S" deformity was seen with stomachto-liver adhesions (Fig. 2, A and B), irregularity with stomach-to-pancreas adhesions (Fig. 3, A and B), and fixation and elevation with adhesions between the stomach and any of the four organs (Fig. 4, A and B; and 5, A and B). In all cases



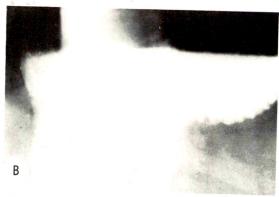


Fig. 5. (A) Sketch of surgical pathology. (B) Roentgen pathology. The greatest elevation was caused by stomach to diaphragm adhesions. These were caused by old shrapnel injury. The entire antrum and body of the stomach are pulled far superiorly with the antrum descending to the duodenum.

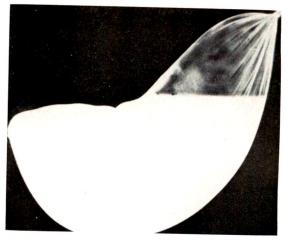


Fig. 6. Condom partially filled with barium in approximate position of stomach. The upright position is necessary to produce an air-barium level.



Fig. 7. The soft wall of the condom, fixed and elevated to produce tenting, illustrates how air may be trapped when the soft wall of the stomach is tented similarly by adhesions.

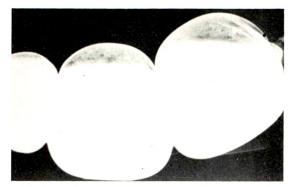


Fig. 8. The condom was constricted to simulate peristalsis and showed that this may aid in trapping air by accentuating the tenting.

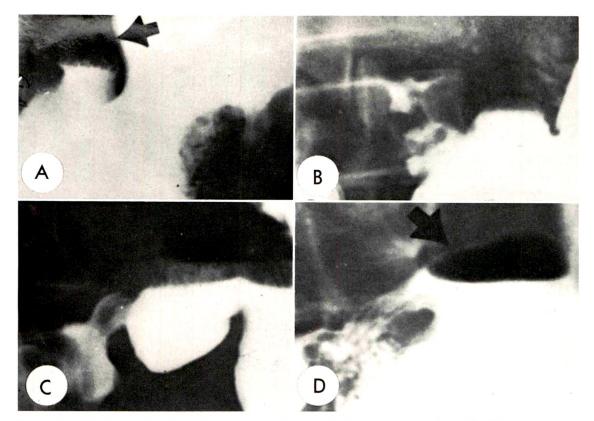


Fig. 9. (A) Single adhesions fixing the stomach to the liver. Arrow shows trapped air. (B) Adhesions causing irregularity and "trapped air" along the lesser curvature of the antrum. When there is "trapped air," such irregularity can safely be ascribed to perigastric adhesions. (C) Large area of "trapped air." There are two fluid levels, one due to gastric secretions and the other to barium. An ulcer crater is present in the duodenum. (D) Constriction of distal antrum with "trapped air" (arrow) in proximal portion.

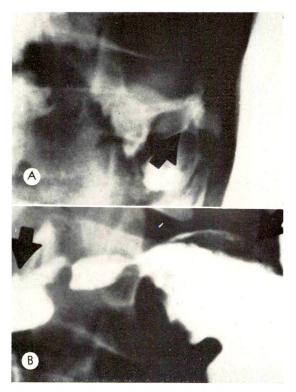


Fig. 10. (A) Arrow points to duodenal ulcer with the antrum ascending to the duodenum. Roentgenogram was made on February 29, 1961. (B) On March 30, 1961 the duodenal ulcer is still visualized (arrow) but now the antrum has been markedly elevated and fixed with "trapped air" and descends to the duodenum.

the stomach wall itself was soft and pliable, and signs of gastric obstruction were not evident.

A comparison of the 37 patients who did not have surgical exploration with the 20 who did showed the roentgen pathology to be almost identical. Therefore, it is logical to assume that the gross pathology in the two groups is equally similar.

## PRINCIPLE OF THE "TRAPPED AIR" SIGN

Roentgen demonstration of the "trapped air" sign is based on three principles: (1) the upright position; (2) fixation and elevation of the stomach wall; and (3) a soft, pliable stomach wall to allow tenting.

To illustrate these principles, a condom was partially filled with barium and roentgenographed in a position similar to that

of the stomach. This showed that the patient must be in an upright position to produce an air-fluid level (Fig. 6). Occasionally, it may be necessary to place the patient supine in the left posterior oblique position for a few minutes and then returned to the upright position to trap the air. The soft, pliable wall of the condom was fixed and elevated to produce tenting and allow air to be trapped (Fig. 7). It was found that peristaltic constrictions are not required but do aid (Fig. 8), since in the absence of such constrictions, the tenting may not be pronounced enough to trap the air. The stomach wall is tented by adhesions in this same manner when it is soft and pliable.

#### DISCUSSION

Thus far, the "trapped air" sign has been a reliable indication of perigastric adhesions. Figure 9, A–D illustrates the various forms that the sign may assume, its appearance depending on the extensiveness of the adhesions and the degree of elevation and fixation. In some cases prior roentgenograms had been taken which did not demonstrate the sign although it appeared on a subsequent study. Figure 10, A and B shows adhesions which developed in a period of 1 month. Undoubtedly, the sign is not seen in all patients that have adhesions, but only in those with fixation and elevation of the antrum.

When there is antral irregularity and deformity, with or without ulceration, the presence of air trapping is a valuable aid in excluding carcinoma (Fig. 11, A and B). If the stomach wall is infiltrated and stiffened as with carcinoma, tenting cannot be produced even though fixation is present. Therefore, the "trapped air" sign should not be seen in cases of carcinoma of the antrum of the stomach. Since 1959, 10 such cases have been studied roentgenographically and this sign was not observed in any (Fig. 12, A and B). No carcinoma has been present in any of the 57 patients in whom the sign was demonstrated. A much larger experience will be required

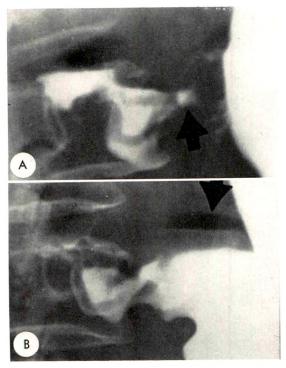


Fig. 11. (A) Antral ulcer with associated irregularity (arrow). (B) Another projection also shows the ulcer, but in addition "trapped air," indicating that the stomach wall is soft and pliable. A benign ulcer was verified at surgery.

before it can be stated with certainty that the sign will not be visualized in cases of antral carcinoma. However, according to our experience, the coexistence of the sign and carcinoma is predicted to be rare.

#### SUMMARY

- 1. The "trapped air" sign is an indication of perigastric adhesions.
- 2. The "trapped air" sign has not been seen in 10 cases of carcinoma of the stomach.
- 3. No carcinoma has been present in 57 patients showing the "trapped air" sign.

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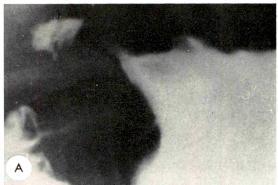




Fig. 12. (A and B) Two different cases of carcinoma of the gastric antrum. There has been no "trapped air" in a total of 10 such cases studied. The thickened gastric wall should prevent tenting.

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## THE CHIEF CAUSE OF ABRUPT ANEMIA

## THE NEGLECTED DUODENAL ULCER

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THE classic picture of *indigestion* in cases of duodenal ulcer is so predominant in the medical mind and so well treated in medical texts that the atypical and insidious *bleeding* ulcer very frequently lies unattended and neglected. Bleeding duodenal ulcer is the foremost cause of gastrointestinal hemorrhage; probably the chief of all sources of abrupt and severe anemias; a frequent cause of *red* blood in the rectum, and, unlike the traditional ulcer, usually without digestive symptoms.

A review of the English language literature<sup>1,3,5,6,8,11,12</sup> reveals that the causes of upper gastrointestinal hemorrhage in the order of incidence are as follows:

the tree tree tree	10110 113.
1. Duodenal ulcer	20-90%
2. Gastric ulcer	combined 65-92%
3. Cirrhosis, portal hyper-	70) 03 9270
tension, or varices	2.7-14.5%
4. Hiatal hernia	0-4%
5. Gastric tumors	0-4%
6. Other causes	0-1%

The character of the rectal blood originating from an upper tract hemorrhage is dependent on the quantity and the time it remains in the bowel. If a large volume of blood from the upper tract causes hypermotility (diarrhea), red blood in the stool is almost unavoidable. Even a small or medium hemorrhage producing diarrhea may be the source of red blood in the rectum. Tarry stool may coexist or follow, but the finding of red blood in the stool can no longer be considered as evidence of the absence of upper tract disease.

Hilsman,<sup>4</sup> from the Gastrointestinal Section at the University of Pennsylvania, showed that citrated blood placed in the upper tract (duodenum to ileum) appeared as *red* blood in the stool if it remained in the tract less than 8 hours; and that 14 hours were required to render it black.

In an effort to focus attention on the bleeding ulcer and to determine the incidence of indigestion, red and black blood in the stool, and the symptoms of severe hemorrhage in these patients, 70 proven cases were analyzed. The data obtained are shown in Table 1.

All cases satisfied the following criteria:

- 1. Confirmed blood in the stool (gross in 67, occult in 3 cases).
- 2. Duodenal ulcer as the sole lesion by roentgenologic examination (if other sources of bleeding were disclosed initially or on follow-up, the case was rejected). Confirmation was attempted as often as possible by securing negative small bowel and colon examinations, repeat studies of the stomach and duodenum and also by operation.
- 3. Improvement or cure by medical or surgical ulcer treatment, or recurrence with further positive roentgenologic diagnosis.

A bleeding duodenal ulcer occurs chiefly in middle age. Our cases ranged from 13 to 86 years of age, the average age being 52 and the median 57. The literature shows that 80 per cent occurred in males. In the present series of patients, 62.8 per cent were males.

The clinical syndrome of bleeding duodenal ulcer is preponderantly that of hemorrhage, not indigestion.

The roentgenologic search for a bleeding point should not stop routinely at the colon when red blood is found in the stool; and the radiologist should consider it his function to suggest examination of the upper tract in these instances.

#### CONCLUSIONS

1. Duodenal ulcer is the commonest cause of upper, and all, gastrointestinal bleeding. It therefore should be a chief

 $\label{eq:Table I} T_{\text{ABLE I}}$  symptoms and signs in 70 cases of duodenal ulcer

Digestive		Hemorrhagic			
Nausea Diarrhea Epigastric Pain or Distress	18 cases (25.7%) 18 cases (25.7%)	(6) D(7) R(7)	eakness izziness ectal Bloo (occult bl ematemes nemia	ood excluded)	32 cases (45.7%) 23 cases (32.8%) 68 cases (97.1%) 11 cases (15.7%) 62 cases (88.5%)
Total	<del></del> 69		Total		196
Total	I	Digestive	69	I	
	Ratio: — He	emorrhagic	=-	8	
No No	Digestive Symptom Symptoms Except	ns Rectal Blood		cases $(34.2\%)$ cases $(15.7\%)$	
Color of Recta	Red	Black and Red	7 ca 30 ca	ses $(42.8\%)$ ses $(10.0\%)$ ses $(42.8\%)$ $5^2$ ccult blood in 3	
		lack Blood Red Blood		= 5/3	
Anen	nia Incidence Under 50% Hemoglobin	Hb. (7.5 gm.	62	cases $(88.5\%)$ cases $(27.1\%)$	
	Minimum			gm.	
	Maximum Average	1	14.5 8.5	gm. gm.	
	Ulcer Diagnosis (	Confirmed by	the Follov	ving Studies	
N	egative Colon	commined by	38 cases	(54.2%0)	
N	egative Small Bowe	1	35 cases	(50.0%)	
R	epeat Stomach and	Duodenum	27 cases	(38.5%) (14.2%)	
$O_{j}$	peration		10 cases	(14.2/0)	

diagnostic consideration when such bleeding is noted.

2. The clinical picture is atypical for the simple uncomplicated ulcer but characteristic for the bleeding ulcer. Symptoms of hemorrhage, not indigestion, are most often present.

3. *Red* blood in the rectum is not uncommon (52.8 per cent in this series).

4. Duodenal ulcer probably is the commonest cause of all abrupt and marked anemias.

5. The radiologist will aid case detection

by suggesting duodenal study when the clinical state coincides with the foregoing description.

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# THE DUODENAL LOOP\*

By FRED O. COE, M.D., CHARLES E. BICKHAM, Jr., M.D., and CAROLYN EDWARDS, M.D.

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INTEREST in the duodenal loop was aroused by erroneous roentgenographic reports in which the duodenum was reported as being "widened." The normal variations of the duodenum are great. If the smooth mucosal pattern of the superior portion of the duodenum is distorted, then the lesions in this segment are usually readily apparent and the diagnosis is easily made. Beginning in the descending portion of the duodenum and continuing distally, transverse ridges or folds, the plicae circulares, of the mucosa appear, and the evaluation of lesions particularly in the descending and ascending portions of the loop is difficult.

A brief review of the embryology of the duodenum and related structures will explain anomalies of rotation. If rotation of the gut does not take place, the duodenojejunal flexure will be on the right, along with the jejunum and the cecum, and the colon will be on the left. If a 90° or partial rotation occurs, the duodenojejunal junction and small intestine are to the right of the spine and the cecum and ascending colon lie high in the abdomen near the midline. If the duodenojejunal junction is in the right upper quadrant, the cecum may be located in any position between the middle portion of the upper abdomen and the right lower quadrant, depending upon the degree of nonrotation.

The brief description taken from Gray's Anatomy of the Human Body<sup>8</sup> is of interest because of the totally different concept between the gross anatomy as seen in the cadaver and that seen by the radiologist in a physiologically functioning person. "Commencing at the pylorus it passes backward, upward and to the right, beneath the quadrate lobe of the liver to the neck of the gall-bladder, varying slightly in direction

according to the degree of distention of the stomach: It then takes a sharp curve and descends along the right margin of the head of the pancreas, for a variable distance, generally to the level of the upper border of the body of the fourth lumbar vertebra. It now takes a second bend, and passes from right to left across the vertebral column. having a slight inclination upward; and on the left side of the vertebral column it ascends for about 2.5 cm., and then ends opposite the second lumbar vertebra in the jejunum. As it unites with the jejunum it turns abruptly forward, forming the duodenojejunal flexure. From the above description it will be seen that the duodenum may be divided into four portions: 1. superior, 2. descending, 3. horizontal and 4. ascending."

#### THE HEPATODUODENAL LIGAMENT

The lesser omentum represents a peritoneal fold extending between the stomach and the superior portions of the duodenum and the liver. It is divided into two parts: the gastrohepatic ligament and the hepatoduodenal ligament. The only portion of the duodenum that is a peritonealized structure with a short mesentery is the ascending segment and thus it may vary in position. Variations in the attachment of the hepatoduodenal ligament determine the position of the duodenal bulb. If the ligament passes farther to the right on to the junction of the superior and descending portions of the duodenum, it may elevate the bulb and the junction with the descending limb becomes a sharp angle. If it extends farther out over the base of the gallbladder, the result will be that the descending portion is pulled to the right. If both the gastrohepatic and the hepatoduodenal ligaments are short,

<sup>\*</sup> From the Radiological Clinic of Drs. Groover, Christie and Merritt, Washington, D. C. Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 2–5, 1962.



Fig. 1. The stomach and the first portion of the duodenum are high. The duodenal loop is "widened."

the stomach and duodenum are high in position and the duodenal loop may seem grossly enlarged (Fig. 1). Widening of the loop has been repeatedly used as a sign of pancreatic tumor, but because of such anatomic variations as cited above, the sign alone is not reliable.

#### THE LIGAMENT OF TREITZ

The ligament of Treitz, muscle of Treitz or musculus suspensorius duodeni, commences at the left crus of the diaphragm near the aortic hiatus. The ligament passes downward to the left of both the celiac trunk and the superior mesenteric artery, dorsal to the pancreas, to be inserted into the superior border of the duodenojejunal flexure and a part of the ascending duodenum. From this, it is continued into the mesentery. The ligament helps to keep the duodenojejunal flexure in position and its length determines whether the flexure lies high or low.

Golden<sup>7</sup> states that the usual location of the duodenojejunal junction is "one or two inches to the left of the spine and that variations in this position are not infrequently seen, with usually a shift to the right so that it overlies the vertebral column." We, too, agree that it usually lies to the left of the spine but we have found that a more consistent location was over the transverse processes of the vertebrae. From the midline it will generally vary from 3.5 cm. to 6.0 cm. to the left. If an anomaly in malrotation of the intestine occurs, then the position will usually shift to the right and may directly overlie the vertebrae or even lie to the right of the spine.

Anteroposterior roentgenograms of patients in the 35° Trendelenburg, horizontal and erect positions were made to see to what extent, if any, variation of the position of the junction occurred (Fig. 2). We found that in the inverted position the junction may lie opposite the twelfth dorsal vertebra, particularly in the hypersthenic individual. There is a great deal of variation in the horizontal position, again depending upon the habitus of the patient, varying from opposite the twelfth dorsal vertebra down to the third lumbar. In the

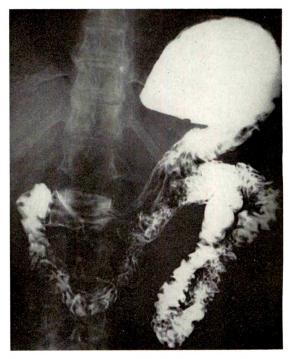


Fig. 2. In the 35 degree Trendelenburg position the duodenojejunal junction overlies the left second lumbar transverse process.

erect position, the junction may descend inferiorly to the level of the fourth lumbar vertebra (Fig. 3). Measurements have shown a shift in the sagittal plane from the Trendelenburg to the erect position to vary from 5.0 cm. up to 8.0 cm. Generally, there was no shift in the horizontal plane. Deep inspiration and expiration studies were made in the anteroposterior horizontal position and the junction was noted to move on an average from 2 cm. to 4 cm. Since the duodenojejunal flexure varies in position in the normal individual, large retroperitoneal lesions may alter its position without any apparent roentgenographic displacement.

# LESIONS AND ABNORMALITIES OF THE DUODENAL LOOP

Duodenal diverticula usually involve the second and third portions of the duodenum. The diverticula of the duodenum consist of a wall of mucosa and submucosa and serosa without musculature, hence they are incapable of contraction and fill and empty by gravity and secondarily to peristalsis of the duodenum.

According to the research of several authors,2,5 diverticula of the duodenum are embryologic remains of false anlage of the liver-pancreatic bud. The normal bud develops into the liver, gallbladder and biliary ducts while the other becomes the pancreas and pancreatic duct. These false buds enlarge later due to internal pressure. Contrary to the description in some textbooks, experience has proved that duodenal diverticula are not usually of pathologic significance. Very rarely has ulcer of a diverticulum been found. Occasionally, the diverticula are so large or numerous that their bulk produces interference with normal physiology. Also cases are found in which diverticula encroach on the ampulla of Vater producing stasis of the common and pancreatic ducts.

The diagnosis of early carcinoma of the head of the pancreas is best made with the "retrospectoscope;" *i.e.*, having found at exploratory operation an early carcinoma,

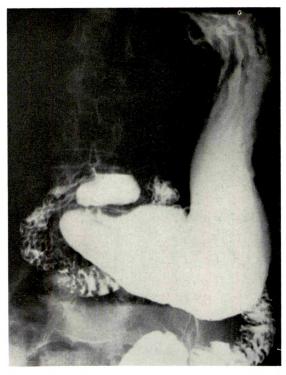


Fig. 3. In the erect position the duodenojejunal junction lies over the left fourth lumbar transverse process.

go back and look at the films of the duodenal loop and see or imagine you see changes which are due to carcinoma. No roentgenologic diagnosis is more reprehensible and only tends to make referring physicians have less faith in radiologic studies.

Carcinoma of the head of the pancreas may produce no recognizable roentgen signs (Fig. 4) or it may cause some alteration and fixation of the mucosal pattern, particularly of the medial aspect of the descending segment (Fig. 5). This latter finding may be such that the radiologist may be uncertain in making the diagnosis, or he may make a wrong diagnosis leading to needless surgery. On the other hand, advanced lesions may completely obstruct the common bile duct and yet the only finding may be a questionable impression upon the apex of the bulb by an enlarged duct. If the duodenal loop is actually widened by a carcinoma, the lesion is usually inoperable.



Fig. 4. Spot roentgenogram of duodenal loop. At surgery a carcinoma of the head of the pancreas measuring 4×6 cm. was found. The common bile duct was totally obstructed and measured approximately 2.5 cm. above the site of obstruction. No demonstrable roentgen signs were present.

Frostberg<sup>4</sup> stated that the "reverse 3" sign was not characteristic of carcinoma as it could be due to edema of the ampulla

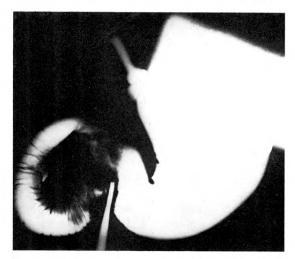


Fig. 5. A 9 cm, sponge was placed beneath autopsy specimen. This shows impression upon the descending portion of the duodenum such as might be caused by a large tumor mass.

caused by either carcinoma or by inflammation in the ampulla. The "reverse 3" sign is due to pressure on the duodenum above and below the ampulla with the ampulla forming the mid-bar of the "reverse 3." This sign, however, is not as frequently seen as reports seem to indicate.

Eyler *et al.*,<sup>3</sup> in 100 cases of carcinoma of the pancreas, made a positive diagnosis in only 24 instances. In a controlled retrospective study, a positive diagnosis of pancreatic enlargement was made in 57 of the 100 cases. An additional 9 cases were thought to be suspicious when routine roentgenograms had not shown the duodenal loop to be well filled.

Lesions of the body of the pancreas rarely affect the duodenal loop, or at least not until they are far advanced; and even then the only roentgen sign may be extrinsic pressure upon the posterior aspect of the lesser curvature of the body of the stomach.

Lymphoma may involve the pancreatic area and present on roentgenograms a suggestion of a widened duodenal loop. If there is other evidence of this disease process, the diagnosis may be suspected (Fig. 6 and 7).

Carcinoma of the duodenum is rare. Carcinoma of the ampulla of Vater may be sus-



Fig. 6. Lymphosarcoma involving the pancreatic area. The loop is widened but there is extrinsic pressure upon the antrum of the stomach.

pected but often cannot be differentiated from edema of the papillae.

Duodenal polyps and pancreatic rests may occur but aside from a confirmation of their presence, the exact roentgen diagnosis often cannot be made.

Chronic arteriomesenteric duodenal occlusion is an entity well known to radiologists,1,6 but less known to other members of the medical profession. This does not pertain to the transient physiologic dilatations of the second portion of the duodenum, but to constant obstruction of the duodenum at the point where the duodenum passes between the aorta and the superior mesenteric artery. There are other conditions which will produce obstruction at this point. In one of our cases an aneurysm of the aorta, pressing forward, closed the triangle between the aorta and the mesenteric artery producing the same syndrome. Inflammation<sup>9</sup> such as lymphadenitis, regional ileitis, pancreatitis or any mass-forming disease may reduce the area of exit for the duodenum and cause obstruction of the second portion of the duodenum.

Atresia or stenosis of any portion of the duodenal loop may be present in the newborn. This demands early diagnosis and immediate surgical relief.

Annular pancreas is caused by a failure of the ventral pancreas to migrate normally to the left behind the duodenum. Various deformities from an overlapping of the posterior duodenal wall to a complete ring may occur.

Pancreatic cysts may also occur and if they are large enough they may definitely cause signs of extrinsic pressure upon the duodenal loop. Rarely calcification may be seen in the region of the cyst.

Herniation of the second portion of the duodenum into the foramen of Winslow is extremely rare. This, of course, produces obstruction to this portion of the duodenum.

Adjoining viscera such as the gallbladder, liver and kidney may also produce extrinsic defects upon the duodenal loop. Aneurysms of the aorta or aortic grafts may rupture

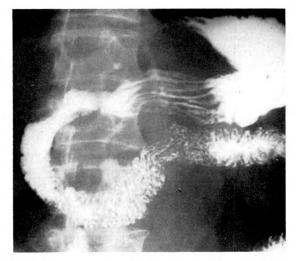


Fig. 7. Same patient as shown in Figure 6. Two years later following radiation therapy, there was a decrease in the size of the duodenal loop.

into the duodenum. Likewise severe extrinsic pressure may produce large hematomas in the duodenum, even with obstruction.

#### SUMMARY

1. The duodenojejunal junction varies in position according to the degree of rotation of the gut in embryologic development. In the "normal" individual the junction lies to the left of the spine but varies in position with posture and respiratory phase.

2. The hepatoduodenal ligament determines the position of the duodenal bulb.

3. Widening of the duodenal loop *per se* cannot be used alone as a diagnostic sign of pathology.

4. Many lesions occur in or about the loop and often the diagnosis may be difficult.

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# AIDS TO DIAGNOSIS OF ACUTE PANCREATITIS BY ROENTGENOLOGIC STUDY\*

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ACUTE inflammation of the pancreas can occur with widely varying degrees of clinical severity. The concept of acute pancreatitis was limited for many years to the entity of hemorrhagic pancreatic necrosis, a fulminating disease characterized by severe pain, vomiting, and a rapid progression to cyanosis, shock, and collapse. Survival was considered rare, and postmortem examination typically revealed hemorrhagic necrosis of the pancreas, retroperitoneal hemorrhage, and extensive areas of peritoneal fat necrosis. In 1933, however, Elman<sup>16</sup> recognized the existence of a milder form of the disease, which he termed interstitial pancreatitis. Instead of necrosis, there was only edema and inflammatory infiltration of the gland and adjacent tissues. Peritoneal fat necrosis, if present, was of limited extent. Although the clinical onset of interstitial pancreatitis may be indistinguishable from that of acute pancreatic necrosis, 7,51 survival is the rule and the acute symptoms actually may subside in 24 to 48 hours.17

Since the realization that acute pancreatitis can be a benign and self-limited disease, it has been detected with a frequency equal to one-half that of perforated ulcer and one-tenth that of acute appendicitis.10,17 Physicians have rarely sought roentgenologic aid for the diagnosis of acute pancreatitis, relying instead on clinical evaluation with particular emphasis on laboratory studies. However, accuracy in diagnosis has not been as high as generally might be believed (Table 1). It is the purpose of this paper to review some of the difficulties in clinical diagnosis of acute pancreatitis, and to present our experience with gastrointestinal roentgen studies as a diagnostic aid.

#### PROBLEMS IN CLINICAL DIAGNOSIS

Acute pancreatitis can masquerade in many clinical images. Pain is almost always present, but the onset of pain can be abrupt or gradual, and it may be felt in the lower rather than in the upper abdomen.<sup>5,41</sup> It radiates to the back in only half of patients.<sup>5,7</sup> Jaundice occurs in about one fourth of patients,<sup>7,41</sup> leading to a frequent

 $T_{ABLE\ I}$  frequency of correct clinical diagnosis in series of cases of acute pancreatitis

A.	Clinical Se	eries		
Author	No. of Patients with Acute Pan- creatitis	No. Correctly Diagnosed Prior to Surgery or Autopsy	Per Cent	
Paxton and Payne, 40				
1948	307	204	66	
Lipp and Aaron,31	0 ,			
1950	44	17	39	
Sullens and Lichten-		,		
stein, 49 1951	50	20	40	
Pollock,41 1959	100	56	56	
Norris and Good,39				
1961	78	27	35	
В.	Autopsy S	eries		
Author	No. of Deaths Due to Acute Pan- creatitis	No. Correctly Diagnosed Ante Mortem	Per Cent	
Moseley and				
Pappas, <sup>37</sup> 1952	17	I	6	
Healey et al., 23 1955	21	9	43	
Donhauser and				
Bigelow, 14 1958	21	3	14	

<sup>\*</sup> From the Department of Radiology, School of Medicine, The University of North Carolina, Chapel Hill, North Carolina.

erroneous diagnosis of acute cholecystitis;31 indeed, some type of biliary tract disease is present in 40 per cent of cases of acute pancreatitis.7,40 Meteorism and emesis, with or without shock, can mimic bowel obstruction or infarction. Massive gastrointestinal hemorrhage is an infrequent but confusing manifestation of acute pancreatitis, 35,36,41 and gross hematuria has been reported.<sup>13</sup> Diarrhea occurs in a few patients.40 Parenchymal and pleural abnormalities often can be detected at the left lung base on physical examination, directing attention to a possible primary intrathoracic disease. 6,31 Acute pancreatitis readily mimics acute cardiac disease:14 electrocardiographic abnormalities were found in 19 of 32 patients with acute pancreatitis examined by Pollock,41 and the electrocardiogram may simulate the patterns of myocardial ischemia or infarction despite the absence of any heart disease. 1,20

Since a bedside diagnosis of acute pancreatitis is virtually impossible, 7,17 physicians for over two decades have relied largely on serum amylase determinations to confirm a suspected diagnosis of pancreatitis. Serum amylase levels greater than 200 units (Somogyi) per 100 ml. have been accepted as evidence of acute pancreatitis,

#### TABLE II

CONDITIONS REPORTED TO CAUSE ELEVATED SERUM AMYLASE LEVELS IN THE ABSENCE OF PRIMARY PANCREATITIS—AND HIGHEST REPORTED AMYLASE LEVEL

Single morphine injection—7869 Acute cholecystitis—1,100<sup>10,22,41,52</sup> Perforated gastroduodenal ulcers—over 1,00010,15,33,38,41,52 Intestinal obstruction—over 1,000<sup>8,10,41,42</sup> Acute appendicitis—over 40010,41 Uremia—over 5007,42 Afferent loop obstruction—over 1,00025 Ruptured spleen-60018,26 Peritonitis—2,5004,8,41,42 Meckel's diverticulitis—80010 Mesenteric adenitis—8004 Ruptured ectopic pregnancy Liver metastases—16,000<sup>15</sup> Abdominal carcinomatosis—80010 Myocardial infarction—80041 Closed head injuries-95046

and elevations of this degree occur in 60 to 80 per cent of cases. 15, 23, 24, 35, 49 Unfortunately, it has been found that a number of other conditions can produce serum amylase levels of 200 to 500 units, and occasionally greater, in the absence of primary pancreatitis (Table II). Serum amylase levels greater than 200 units have been reported in about half of patients with gastroduodenal perforations 10,15 or intestinal obstruction. 10

Taking note of the other conditions which may elevate serum amylase, Bockus<sup>6</sup> has stated that a diagnosis of acute pancreatitis is reasonably certain when the serum amylase level is over 500 units (in the absence of opiate administration or uremia). However, amylase elevations of this degree will be found in only about one half of patients with acute pancreatitis,<sup>7,15,31,35,51</sup> particularly if there is any delay in performing the tests. Amylase is excreted rapidly by normal kidneys, and serum amylase levels usually are elevated only during the first 48 to 72 hours of acute pancreatitis, whether or not symptoms continue.

Elevation of lipase in blood and urine persists longer than amylase, but lipase determinations require 24 hours of incubation and are not widely used. The plasma antithrombin titer seemed promising as a test for pancreatitis, but reports of its usefulness have been variable.<sup>32</sup>

#### ROENTGENOLOGIC METHODS

It is evident that diagnosis of acute pancreatitis by determination of circulating enzymes is neither entirely specific nor always possible. The roentgenologic diagnosis of acute pancreatitis is based upon demonstration of the gross anatomic and functional changes accompanying the inflammatory process. With acute inflammation, of either interstitial or hemorrhagic type, the pancreas can enlarge to two or three times normal size. <sup>5,50</sup> The surrounding peritoneal surfaces and supporting tissues become inflamed and edematous, probably secondary to permeation by pan-

creatic enzymes and to overload of local lymphatic drainage. The duodenum becomes congested and edematous.<sup>50</sup> Pancreatic enzymes are carried into the chest by diaphragmatic lymphatics, with resultant inflammation. Even pericardial fat necrosis has been found at postmortem examination of patients with acute pancreatitis.<sup>40</sup>

Roentgenograms of the chest and abdomen show some abnormality in 20 to 50 per cent of cases. 7,41,47 Pleural fluid, basal foci of pulmonary consolidation, and local or general intestinal distention can occur. Absence of gas in the transverse colon is described as a sign of acute pancreatitis, due to the extension of inflammation through the mesocolon and consequent colonic spasm. 48 None of the plain roentgenographic findings are specific, however.

Failure of opacification of the gallbladder after oral ingestion of contrast medium, in the absence of liver failure, is an accepted criterion for the diagnosis of acute cholecystitis. However, in one half of patients with acute pancreatitis the gallbladder also fails to concentrate contrast medium, <sup>29,45</sup> even though the gallbladder is subsequently found to be normal. Cholecystography, then, may actually be misleading. Even with intravenous cholangiography, no biliary opacification occurs in one third of cases of acute pancreatitis, <sup>28</sup> thus allowing no differentiation between acute cholecystitis and pancreatitis.

Roentgenographic examination of the upper gastrointestinal tract with barium, however, can reveal more specific changes of acute pancreatitis (Table III). As early as 1928 Hultén<sup>27</sup> described anterior displacement of the stomach, atony of the duodenum, and coarsened duodenal mucosal folds in 14 patients with acute pancreatitis. The pancreatic area was sensitive to pressure. Case<sup>12</sup> described enlargement of the duodenal loop as well as stasis of barium in the dependent portions of the duodenum. Metheny and his colleagues,<sup>34</sup> in their cases of acute pancreatitis, found similar changes evident up to 3 weeks after

#### TABLE III

PRESUMED BASIS OF ANATOMIC-PHYSIOLOGIC CHANGES EVIDENT ON UPPER GASTROINTESTINAL EXAMI-NATION IN ACUTE PANCREATITIS

### Enlarged Pancreas

- 1. Anterior displacement of stomach
- 2. Flattening of medial duodenal mucosal folds
- 3. Widened duodenal loop
- 4. Partial obstruction at ligament of Treitz
- 5. Inverted "3" sign

Peri-pancreatic Inflammation and Edema

- 1. Dilatation of duodenum, with local ileus
- 2. Edema of duodenal mucosal folds
- Gastric displacement due to accumulation of fluid in the lesser peritoneal sac
- 4. Enlarged and distorted gastric rugal folds
- 5. Enlarged papilla of Vater

the onset of symptoms, long after serum amylase values had returned to normal. Glenn and Baylin<sup>19</sup> emphasized persistent spasm in the descending duodenum and coarse duodenal mucosal folds in acute pancreatitis, as well as displacement and distortion of the stomach by the enlarged pancreas. Collections of fluid in the lesser peritoneal sac may contribute to the anterior displacement of the stomach.2 Mucosal alterations in the distal stomach rarely may simulate infiltrating carcinoma. 41 Flattening of the medial wall of the duodenum and partial obstruction near the ligament of Treitz have been described.21 Stein et al.47 found an enlarged papilla of Vater to be the most frequent reliable roentgen finding.

Twenty-six patients, all severely ill with acute pancreatitis, were examined within the first 48 hours of illness by Bergkvist and Seldinger.<sup>3</sup> Pancreatic enlargement was detected initially in 10, and in a few more in retrospect. Reduced duodenal motility or paresis was seen in 24, with frequent failure of barium to pass beyond the second portion of the duodenum. Although transient duodenal stasis may accompany acute cholecystitis, it was much more marked with pancreatitis.

When roentgenograms or reports are reviewed in series of cases of acute pancreatitis, some abnormality by upper gastrointestinal examination is found in 50 to 60 per cent.<sup>7,41,47</sup> Pollock<sup>41</sup> suggested in 1959 that examination by barium meal early in the course of the disease might be of diagnostic value, but there are only two reports<sup>21,34</sup> of deliberate efforts to diagnose pancreatitis on the basis of roentgenologic study. The frequency of accurate diagnosis was not stated.

#### NEW MATERIAL

A review of our hospital's records from 1954 to 1962 revealed that 36 patients with acute pancreatitis have been admitted within 2 weeks after onset of their illness. The majority was seen within 3 days. Cases of pancreatitis associated with penetrating peptic ulcer were not included in this study, nor were cases of known chronic pancreatitis with recurrent pain. No patient is included twice in this series.

An elevation of serum amylase above 300 units per 100 ml. of serum was present in 14 of the 32 patients in whom determinations were done. Pancreatitis was diagnosed or confirmed by surgical findings in 12, and at autopsy in 4 additional patients.

Roentgenographic examination of the upper gastrointestinal tract with barium was done in 23 patients. In 2, conditions were unsatisfactory for evaluation of possible pancreatitis; the stomach was full of fluid in one, and the other patient had had a subtotal gastrectomy and gastrojejunostomy in the past.

The roentgenographic reports and studies were reviewed in the 21 patients with satisfactory examinations. Examinations had been done by various members of the attending and resident staff. Six examinations were considered normal although, on review, findings suggestive of pancreatitis were evident in 2 of these. In 15 examinations, or 71 per cent, the examiner reported some abnormality in relation to the pancreas. The roentgenologic findings and diagnoses are listed in Table IV.

The average interval between onset of symptoms and roentgenologic study was 8 days in both the positive and negative

TABLE IV

ROENTGENOLOGIC FINDINGS BY BARIUM STUDY IN 15
PATIENTS WITH ABNORMAL EXAMINATIONS
DURING ACUTE PANCREATITIS

Ι.	Findings		
	Edema or thickening of duodenal muco-		
	sal folds	1.3	
	Anterior displacement of stomach*	ΙI	
	Atony or stasis in duodenum	IO	
	Dilated duodenum	8	
	Flattened medial duodenal mucosal folds	7	
	Widened duodenal loop	3	
	Narrowing of descending duodenum	3	
	Distorted gastric antrum	3	
	Inverted "3" sign	2	
	Partial obstruction at distal duodenum	2	
	Enlarged papilla of Vater	I	
	Diagnoses		
	Pancreatitis diagnosed or suggested	IO	
	Carcinoma of pancreas	3	
	Retrogastric mass	2	

<sup>\*</sup> Based on measurements of the retrogastric space.<sup>44</sup> An additional 2 patients had measurements at the upper limit of normal.

groups. No patients were examined during the first 48 hours of their illness. Examinations as late as 15 days after the onset of illness have shown characteristic changes of acute pancreatitis. The shortest interval in which a completely normal examination followed a positive study was 3 weeks.

None of the 21 patients with barium examinations came to autopsy. In 7, the diagnosis of pancreatitis was confirmed at later surgical exploration. Six had had a roentgenologic diagnosis of pancreatic disease, and in 1 the barium study had been considered normal.

In each of the 5 cases of acute pancreatitis in which the roentgenologic findings were interpreted as carcinoma of the pancreas or a retrogastric mass, the examination had been done 10 days or more after the beginning of symptoms. In each case, subsequent surgery or clinical follow-up, or both, excluded pancreatic malignancy. Repeat gastrointestinal studies were done in 3 of the cases. Two were completely normal after 6 weeks and 15 months, respectively; in the other patient, the abnormal findings had partly regressed at exami-

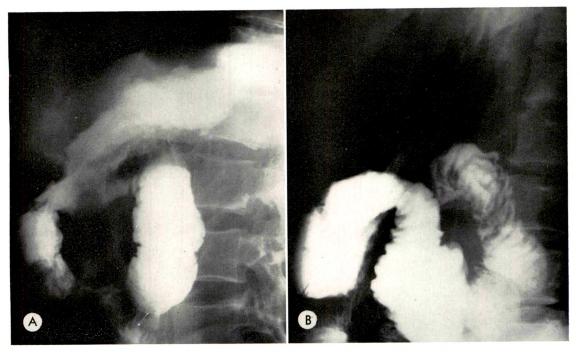


Fig. 1. (A and B) Roentgenograms made in right lateral recumbent position are shown from the examinations of 2 patients with acute pancreatitis. The distal stomach is displaced anteriorly from the spine by the enlarged pancreas and the adjacent inflammatory process. The descending duodenum is also displaced anteriorly in B. The diagnosis of acute pancreatitis was made on clinical grounds in A and after surgical exploration in B. In both cases, the roentgenologic diagnosis was acute pancreatitis. See also Figure 2, A and B.

nation I week later. This patient is alive and well 3 years later.

Gastrointestinal examination of patients with acute pancreatitis usually reveals no intrinsic abnormality of the esophagus or stomach. As the patient is rotated, the distal portion of the stomach appears to move across the abdomen more rapidly than normal, due to its anterior diplacement by the enlarged pancreas. The anterior displacement of the gastric antrum is confirmed by roentgenograms made in lateral position (Fig.1, A and B). Gastric emptying begins with little delay, and the duodenal bulb often appears normal. However, subsequent abrupt stasis of barium in the paretic descending duodenum is quite striking at fluoroscopy. The descending duodenum often is dilated, and there usually is absence of normal peristaltic activity (Fig. 2, A and B). Occasional retroperistaltic contractions may be seen. Barium may remain for many minutes in the atonic duodenum, and it appears finally to be pushed from the duodenum only as more barium enters from the stomach. If only a small amount of barium has been ingested, it may all pool in the paretic duodenum (Fig. 3).

Edema of duodenal mucosal folds may be partly obscured by the density of the barium in the duodenum, but it can be demonstrated on roentgenograms made with compression (Fig. 4, A and B). Stiffened plicae circulares encircling the atonic duodenum can produce an appearance which resembles the haustral appearance of colon more than the normal feathery image of duodenal mucosa (Fig. 5, A and B). The stiff encircling folds show little change in appearance or direction as barium slowly passes through the duodenum. Thickening of the plicae circulares was well demonstrated on a postoperative

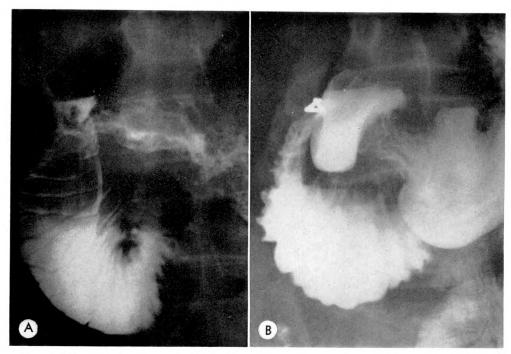


Fig. 2. (A and B) Roentgenograms made during fluoroscopy, with the patients in upright position, are shown from the examinations of the same 2 patients as in Figure 1, A and B. Barium is seen to pool in the dependent portion of the paretic, dilated duodenum. In B, air-fluid levels are evident between the plicae circulares.

pancreatodochogram in one patient (Fig. 6).



Occasionally, the descending duodenum is not dilated but is narrowed in some portion. The narrowing apparently is not due to spasm, since it appears constant and even rigid at fluoroscopy, and it probably is secondary to compression by the enlarged pancreas and the adjacent inflammatory reaction. Edema of duodenal mucosa may be striking in the area adjacent to the compression (Fig. 7,  $\mathcal{A}$  and  $\mathcal{B}$ ). If symptoms have subsided and mucosal edema is not marked, the impression on the duodenal loop may be mistaken for pancreatic malignancy if the examiner is unaware of the recent acute illness (Fig. 8).

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Fig. 3. In a patient with acute pancreatitis, all of the barium has collected in the duodenum by the end of the examination, due to the local ileus. Acute pancreatitis was confirmed at subsequent surgical exploration.

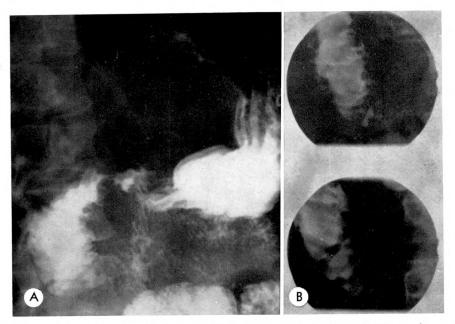


Fig. 4. (A) Barium in the dilated duodenum partly obscures mucosal edema, but it can be seen on roent-genograms (B) made with the compression cone. Acute pancreatitis was diagnosed on the basis of clinical and roentgenologic findings in this patient.

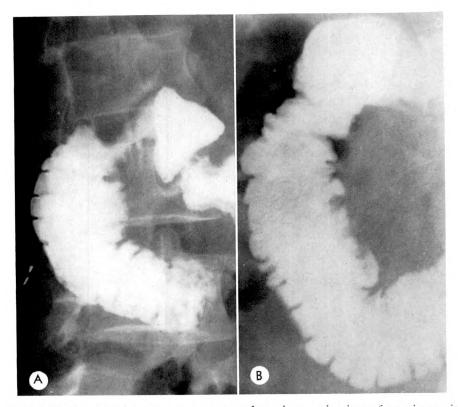


Fig. 5. (A and B) Fluoroscopic spot roentgenograms from the examinations of 2 patients with acute pancreatitis illustrate the haustra-like appearance of the duodenal silhouette.



Fig. 6. Marked thickening of the duodenal plicae circulares is illustrated after injection of contrast medium via a pancreostomy tube. Acute pancreatitis had been found at surgical exploration 5 days earlier.

Repeat gastrointestinal examinations were done, 3 weeks or more after the first study, in 5 patients who did not have any intervening surgical procedure. In each, the later examination revealed normal appear-

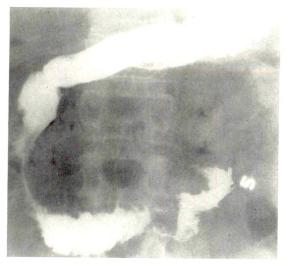


Fig. 8. A persistent impression against the medial aspect of the descending duodenum was evident in a patient with acute pancreatitis, 11 days after the onset of illness. Symptoms had completely subsided at this time. Edema of duodenal mucosa is present but is less striking than in Figure 7, A and B. Gastrointestinal examination 16 months later was normal.

ance and function of the stomach and duodenum. A comparison of serial examinations serves to emphasize the abnormal-

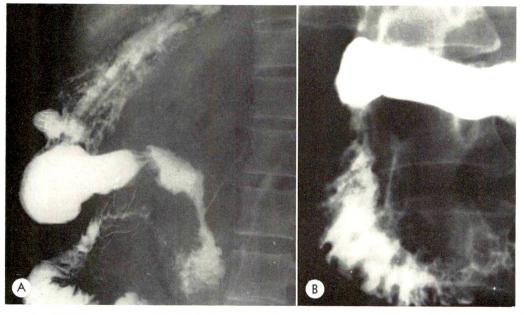


Fig. 7. (A and B) Two roentgenograms are shown from the examination of a patient with acute pancreatitis, done 10 days after the onset of symptoms. Mild pain was still present. Persistent narrowing of the upper descending duodenum was evident at fluoroscopy. Edema of duodenal mucosa is apparent. The upper gastrointestinal tract appeared normal on examination 3 weeks later.

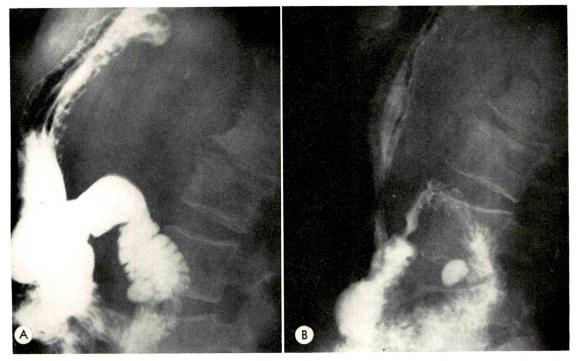


Fig. 9. In a patient with acute pancreatitis, the first gastrointestinal examination (A) was done 13 days after the onset of illness. The entire stomach was displaced anteriorly; the descending duodenum was dilated, with stasis of barium in the duodenum. Repeat examination (B) 5 months later showed normal position and appearance of the stomach and duodenum. Duodenal peristalsis was active, with prompt emptying of barium from the duodenum. A duodenal diverticulum was present.

ities present during acute pancreatitis (Fig. 9, A and B).

From the diagnostic files of the Department of Radiology, 2 additional cases were found in which a roentgenologic diagnosis of pancreatitis had been suggested by barium study. In both, the retrogastric space was abnormally wide and edema of duodenal mucosal folds was evident. Both patients had had acute abdominal pain a few days before being examined. Serum amylase was determined in one patient, 10 days after the onset of pain, and was normal. The final discharge diagnoses in the hospital records were alcoholic gastritis in one and psychophysiologic gastrointestinal reaction in the other.

#### DISCUSSION

Accurate diagnosis of acute pancreatitis is of more than academic interest. Conservative treatment is indicated in uncomplicated acute pancreatitis, 8,43 and mor-

tality may be doubled if surgical exploration is done because of an erroneous diagnosis. 40

Although a few patients never have any detectable elevation of serum amylase, the diagnosis of acute pancreatitis usually can be made on clinical and laboratory evidence if the patient is seen within the first 48 hours of illness. Roentgenologic methods of diagnosis probably will be of greatest value in patients who are seen 3 or more days after the onset of their illness, when serum amylase values usually have returned to normal.

Anterior displacement of the stomach may be caused by a number of conditions, including upper retroperitoneal neoplasms, cysts in and about the pancreas, and enlarged lymph nodes. Duodenal paresis of limited degree may be found with acute cholecystitis or after recent upper abdominal surgery. However, an enlargement in the region of the pancreas in combina-

tion with the typical motor changes in the duodenum has been seen only in the presence of pancreatitis. Although the present series includes only cases of primary acute pancreatitis, we and others<sup>21</sup> have seen similar changes in pancreatitis secondary to penetrating ulcers and during acute exacerbations of chronic relapsing parcreatitis.

To the best of our knowledge, a roentgenologic diagnosis of acute pancreatitis has not been made in a patient subsequently proved not to have pancreatitis. Such errors may occur. However, from our experience it appears that a reasonably certain diagnosis of acute pancreatitis can be based upon demonstration of the characteristic changes by barium study, correlated with the recent clinical history. The barium study can confirm a clinical suspicion of acute pancreatitis when the elevation of serum amylase is in the questionable range. In patients with pancreatitis in whom the serum amylase levels are normal, demonstration of the typical findings by gastrointestinal examination may be the only objective evidence of the nature of the acute illness. In all cases, the diagnosis is further confirmed by a subsequent return of normal findings by barium study.

The changes produced by subsiding pancreatitis have been mistaken for pancreatic malignancy. This error should be infrequent if attention is given to the recent clinical history and to the motor and mucosal abnormalities in the duodenum. A subsequent normal examination also helps to exclude malignancy as the cause of the pancreatic enlargement.

Unfortunately, acute pancreatitis cannot be excluded on the basis of a normal gastrointestinal examination. However, roentgenologic changes are present in the majority of cases, and their absence should raise a question as to whether an elevated serum amylase is actually due to primary acute pancreatitis. Patients with high serum amylase values have died of perforated ulcer<sup>52</sup> or intestinal obstruction<sup>42</sup> while on conservative management with

an erroneous diagnosis of acute pancreatitis. Barium study in cases of suspected pancreatitis might prevent such errors.

#### SUMMARY

The clinical diagnosis of acute pancreatitis is difficult, and an elevation of serum amylase is not always present. Furthermore, high serum amylase levels are not completely specific for acute pancreatitis.

During acute pancreatitis, the pancreatic enlargement and peri-pancreatic inflammatory reaction result in changes which can be detected by examination of the upper gastrointestinal tract with barium. Of 21 patients with acute pancreatitis, abnormal findings were detected in 15 at the time of barium study. The roentgenologic abnormalities may be present for 2 weeks or more after onset of symptoms.

The combination of roentgenologic findings that is seen with acute pancreatitis has not been observed in other conditions. A roentgenologic diagnosis of acute pancreatitis should be confirmed by subsequent demonstration of a return to normal appearance and function of the stomach and duodenum.

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# DUODENAL REFLUX DURING CHOLANGIOGRAPHY SIMULATING A RE-FORMED GALLBLADDER\*

By BERNARD S. EPSTEIN, M.D., and JACOB SMULEWICZ, M.D. NEW HYDE PARK, NEW YORK

A PROBLEM which is occasionally encountered in the interpretation of cholangiograms in patients examined after cholecystectomy is the presence of a somewhat circular shadow lateral to the common bile duct approximately at the level of the insertion of the cystic duct. In the past this had caused concern as to whether it represented a dilated remnant of cystic duct or possibly regeneration of a portion of the gallbladder.

A clue to the true nature of this shadow was provided by a patient who had symptoms consistent with the so-called "postcholecystectomy syndrome" for about 5 years after operation. This rounded opacity was reported as representing dilatation of the cystic duct remnant or a re-formed gallbladder (Fig. 1). At operation the ductal system was normal and there was no indication of a dilatation in the biliary tract corresponding to this opacity. A few days later another patient with a similar roentgenologic picture came up for consideration. On laminagrams reflux of biligrafin up the duodenal loop, opacifying the loop and the duodenal bulb, was demonstrated (Fig. 2B). The shadow of the duodenal bulb corresponded exactly to that seen on the intravenous cholangiograms (Fig. 2A). Thereupon the patient was given some oral hypaque, and the bulb was definitely identified as the cause of the confusing paraductal density.

In order to check on this observation, 25 postoperative T-tube cholangingrams were reviewed, and in 10 of these it was apparent that the reflux of contrast material into the duodenum provided opacification of the duodenal bulb in the location described (Fig. 2C).

Intravenous cholangiography provided another useful bit of information in a few



Fig. 1. Laminagram of a postcholecystectomy intravenous cholangiogram of a 53 year old female made because of persistent symptoms of nausea, occasional vomiting, and pain in the right upper quadrant. The biligrafin collecting lateral to the midportion of the common duct was considered as possibly a re-formed gallbladder. At operation a tiny cystic duct stump was found, much smaller than the shadow caused by the contrast medium.

patients in whom subtotal gastrectomies had been performed and visualization of the afferent loop was desirable (Fig. 3, A and B). In some of these patients, it was not possible to get barium to enter the afferent loop during gastrointestinal examinations. Adequate information as to the position and caliber of the loop was obtained by means of intravenous cholangiography. The contrast material passing through the duodenum and proximal jejunum afforded information as to the approximate size and caliber of this loop.

Our observations are in agreement with

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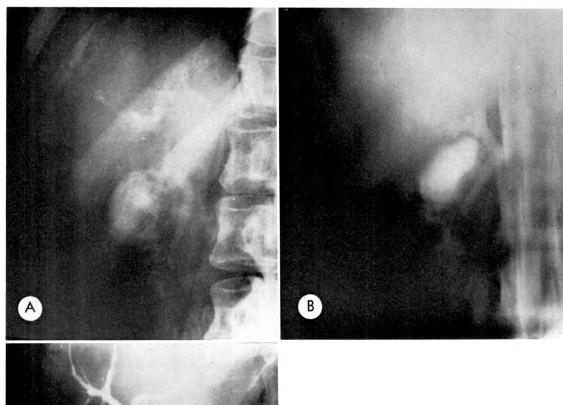


Fig. 2. (A) Intravenous cholangiogram of a 59 year old woman who had had a cholecystectomy 30 years previously. The clinical diagnosis was possible pancreatitis or post-cholecystectomy syndrome. The intravenous cholangiogram reveals the contrast material passing through the common duct into the duodenum. (B) Laminagram of the same patient. The biligrafin outlines the duodenal bulb. (C) T-tube cholangiogram 7 days after cholecystectomy in another patient. The contrast material passes from the common duct into the duodenal bulb.

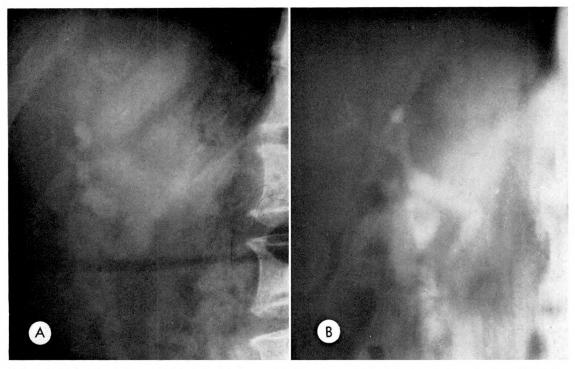


Fig. 3. (A) Intravenous cholangiogram in a 53 year old woman who had had a cholecystectomy for cholecystitis and a subtotal gastrectomy for a duodenal ulcer. The clinical diagnosis was marginal ulcer or common duct stone. Intravenous cholangiogram reveals biligrafin filling a normal ductal system satisfactorily. The contrast material passes into the duodenum and the proximal loops of the jejunum which are of normal caliber. (B) Laminagram of the same patient. The opacification of the loops of the bowel is somewhat better demonstrated.

those reported by Naegele and Huwe, who noted a similar change in 48 out of 103 patients who had had cholecystectomies.

#### SUMMARY

A rounded or somewhat triangular density in immediate proximity to the lateral aspect of the common duct on intravenous cholangiograms often is due to reflux of the contrast material from the duodenal sweep into the duodenal bulb. It should not be mistaken for a pathologic change. This observation is best made on laminagrams and

is considerably strengthened by the identification of opaque material in the descending loop of the duodenum.

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# EMPHYSEMATOUS CHOLECYSTITIS

By LUIS BLUM, M.D.,\* and ALBERTO STAGG, M.D.†

EMPHYSEMATOUS cholecystitis, also known as pneumocholecystitis, cholecystitis emphysematosa, pyopneumocholecystitis and acute gaseous cholecystitis, is a rare infectious condition of the gallbladder characterized by gas in the lumen and/ or in the wall of the gallbladder and in the pericholecystic tissue.<sup>16</sup> There are discrepancies regarding the number of cases reported in the world literature. While Skodan<sup>15</sup> mentioned that there were only 39 cases prior to 1960, Heifetz<sup>5</sup> collected 52 cases prior to March, 1956, and Wilson<sup>18</sup> had collected 28 cases prior to January, 1958. In any event, it can be assumed that the number of cases is around 50 up to the present time. Since the majority of these have been reported since 1948, it seems evident that the rarity of the condition is diminishing due to the awareness of the disease and the ability to make the correct diagnosis.10

Different organisms have been isolated and cultured from the gallbladder and duodenum in this disease. The organisms most commonly found have been *Clostridium welchii*, *Clostridium oedematiens*, and *E. coli*. Numerous types of organisms, including these, are found in normal gallbladders and do not necessarily cause infection. La Cour and O'Neil<sup>9</sup> state that the liver and bile radicles are a normal habitat for the gram positive anaerobic organism.

There is evidence to show that cholecystitis does not occur merely as a result of the presence of bacteria in the lumen of the gallbladder. Injury to the wall of the gallbladder may be a more significant factor in the infection than the presence of the bacteria. Other factors which may be even more important than the presence of the organisms are reflux of pancreatic juice, reflux of gastric juice, high concentration of

bile salts within the gallbladder, obstruction of the cystic duct, and anoxemia within the wall of the gallbladder brought about by pressure from within or without. In other words, it can be said that anatomical, mechanical, metabolic, circulatory and chemical factors are as important, if not more important, than infection in initiating gallbladder disease.

In some of the cases that have been treated surgically, a gas forming organism has not been recovered from the gall-bladder. It is quite probable that the antibiotic and sulfa drugs used before surgery in many of these cases have been responsible for the failure to recover the organism at the time of surgery.

Diabetes mellitus has been associated with pneumocholecystitis in 26 per cent of the cases. Emphysematous cholecystitis is more often seen in men (ratio 5:1)<sup>16</sup> than in women. Biliary calculi are frequently associated and seem to predispose to the production of this disease. The diagnosis of acute emphysematous cholecystitis is based primarily upon roentgen findings. Clinical signs and symptoms (nausea, vomiting, right upper quadrant pain and tenderness), history and laboratory tests are the same as in any case of acute cholecystitis.

#### ROENTGEN FINDINGS

In pneumocholecystitis, the roentgen appearance varies with the stage of the disease. The plain roentgenogram of the abdomen may show a mottled or homogeneous gas shadow in the right upper quadrant of the abdomen, round or pearshaped and conforming to the size, shape and position of the gallbladder. In the erect position, a fluid level is often seen although the absence of a fluid level in the presence of a gas filled gallbladder has been de-

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scribed as a specific sign of pneumochole-cystitis. The presence of the fluid level merely indicates that there is fluid, either bile or purulent exudate, in addition to the gas. In some cases, calculi may be seen within the gallbladder shadow. If these can be conclusively identified as biliary calculi by the presence of fissures (stellate radio-lucencies within the calculi), an absolute diagnosis can be established. The presence of gas within the lumen of the gallbladder is apparently the first stage of the disease.

A concentric ring of lesser gaseous density surrounding the gallbladder, usually involving first the fundus and then extending completely around the viscus, represents the second stage of the disease. At the beginning, the gaseous ring-like shadow may be uniformly demarcated.3 Later, the gas is apparently absorbed from within the lumen and the concentric, smooth, well defined ring that surrounds the gallbladder becomes streaked and bubble-like. This phenomenon is produced by the separation of the muscularis from the mucous membrane. The sequence of events is in accordance with the findings from experimental studies by Heifetz and Wyloge.7 Through a cannula inserted in the lumen, they injected intact gallbladders obtained at surgery or post mortem, normal and diseased, with air. The first change noted during progressive inflation was leakage of air into the perimuscular layer in the region of the cystic duct. After further inflation, the air diffused into the perimuscularis, spread gradually to the fundus and then erupted to the outside. The latter finding would explain the presence of gas in the pericholecystic area in the absence of gangrene of the gallbladder wall and would also explain why, after absorption of the gas, some of these patients recover without surgery. There is striking similarity to these events and those seen in acute emphysematous cholecystitis. At times, the combination of the two pictures described above and, in addition, the presence of gas bubbles separated from the concentric ring indicating

that there is gas in the pericholecystic tissues may be seen.

# DIFFERENTIAL DIAGNOSIS

The considerations in differential diagnosis are: (1) gas in the duodenal bulb or in some other portion of the gastrointestinal tract; (2) fistula between the gastrointestinal tract and the biliary system; (3) abscess due to gas forming infection, having its origin outside of the biliary tract; and (4) poor admixing of bile and opaque material during intravenous cholecystography. The radiolucent gallbladder can usually be readily distinguished from a portion of the gastrointestinal tract by the size, shape and position of the shadow and its constancy with change in position of the patient. If there is any question, examination of the gastrointestinal tract with opaque material will prove the extrinsic location of the radiolucent shadow.

Incompetence of the sphincter of Oddi and fistulous communication with the gastrointestinal tract result in gas in the biliary ducts with or without gas in the gallbladder wall, whereas pneumocholecystitis rarely, if ever, shows gas in the ducts. <sup>12</sup> The majority of fistulous tracts are surgical in origin and the history, scar of surgery, and the demonstration of the communication by gastrointestinal studies establish the diagnosis. An incompetent sphincter or a spontaneous fistula must be demonstrated by the gastrointestinal study.

Other conditions simulating pneumocho-

lecystitis are rare. A relatively high gascontaining appendiceal abscess, particularly if it contains one or more coproliths, may cause confusion; however, the gas shadow is not likely to simulate a gallbladder, and the coproliths are ovoid rather than round or facetted and never show a stellate fissure as occasionally seen in gallstones (Fig. 1). Cholecystograms would probably demonstrate a normal gallblad-

probably demonstrate a normal gallbladder. Lipomatosis has been reported by Kommerell (cited by Bell *et al.*<sup>2</sup>) but is apparently extremely rare. He described a



Fig. 1. Appendiceal abscess following perforation of appendix by coproliths. Large irregular ovoid gas shadow and three ovoid calcifications (coproliths) in cavity of abscess are seen. Mottled radiolucencies inferior to the large collection represent gas in the wall of the abscess.

ring of radiolucent shadows due to fat in the gallbladder wall, but stated that in lipomatosis there is no fluid level and there is no change in appearance from day to day or with change in patient's position.

Some of the opaque media used for cholecystography result in a sharply demarcated radiolucency with convex border which apparently represents relatively viscous bile which does not mix freely with the new opacified bile entering from the liver. This radiolucency is not as black as a corresponding quantity of gas would be, is dependent in the erect position, and shows a

convex upper margin rather than a fluid level (Fig. 2, A, B and C).

## REPORT OF CASES

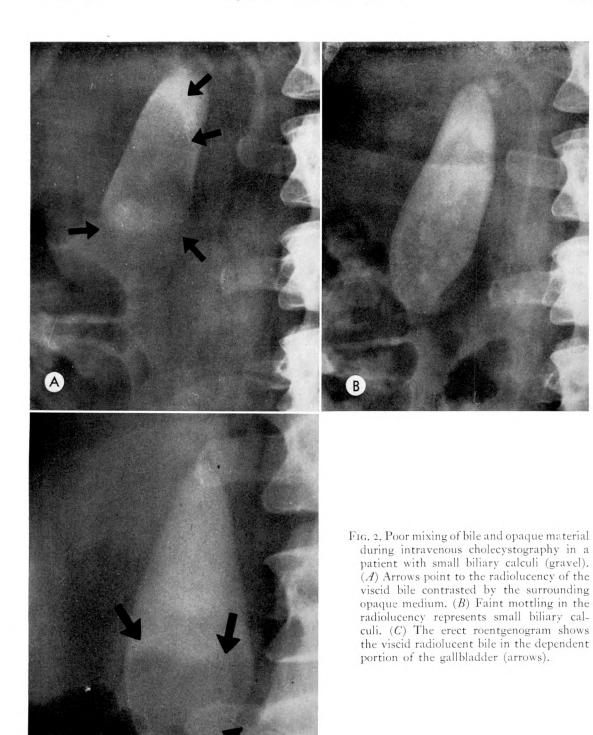
Case I (Fig. 3, A, B and C). A 31 year old male was admitted to Hospital del Seguro Social, Guayaquil, Ecuador, on January 1, 1962, complaining of severe constant right upper quadrant pain of 24 hours' duration accompanied by nausea, vomiting, chills and fever. The past history disclosed that he had had a similar episode 3 months previously but symptoms had dissappeared rapidly without treatment. There was no history of jaundice.

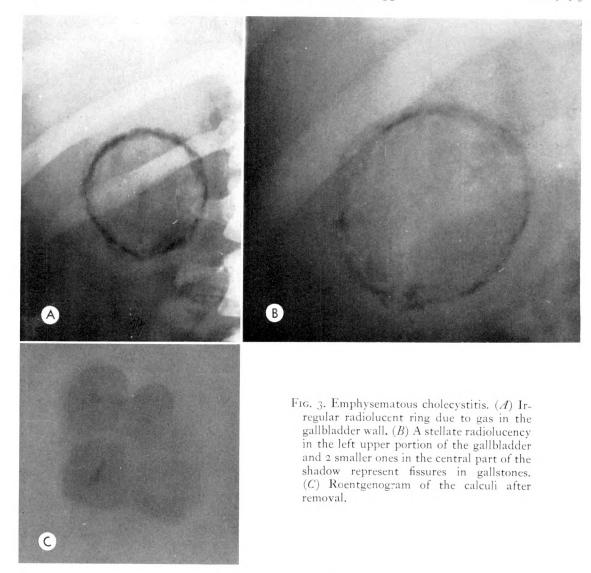
Physical examination revealed a patient with moderate jaundice and in acute distress. There was epigastric tenderness but no palpable mass. The temperature on admission was 38.5° C., the white blood cell count 17,550 with 75 per cent neutrophils; blood sugar was normal.

A roentgenogram of the abdomen demonstrated a ring-like radiolucency, 4 cm. in diameter, in the right upper quadrant, the size and position corresponding to that of a distended gallbladder. Within the radiolucent ring, gas containing biliary calculi were identified. Intravenous cholangiography failed to opacify either the gallbladder or the biliary ducts. Upper gastrointestinal studies and colon examination excluded fistulous communication and showed the radiolucent ring to be outside of the gastrointestinal tract.

The patient was treated with 1 gm. of chloramphenical daily and signs and symptoms improved steadily after the fifth day. The gas in the gallbladder gradually decreased in amount over a  $3\frac{1}{2}$  week period.

Subsequent elective cholecystectomy revealed a slightly distended gallbladder with a necrotic spot in the fundus. The lumen contained black, gritty material and multiple stones, some with fissures, but no gas was detected in the gallbladder at the time of surgery. The entire mucosa was separated from the muscularis. Because of technical difficulties, a cholecystostomy was performed instead of a cholecystectomy. Culture for anaerobic organisms was negative. The postoperative course was uneventful. Fifteen days after surgery, cholangiography through the cholecystostomy tube revealed a normal cystic and common duct. The patient was discharged March 6, 1962, in good condition.





Case II (Fig. 4, A and B). A 68 year old male was admitted to Jefferson Davis Hospital, Houston, Texas, because of severe right upper quadrant pain and tenderness, fever and leukocytosis.

Roentgen examination revealed a gas distended large and small intestine consistent with paralytic ileus and a pear-shaped gas shadow in the right upper quadrant suggestive of gall-bladder. An erect roentgenogram showed a fluid level, and gas outlined the adjacent portion of the cystic duct identifying the organ with certainty. No stones were noted nor was there gas in the biliary ducts.

Cholecystectomy was performed as an emergency procedure and an acutely inflamed

gallbladder filled with gas was removed. Unfortunately, under the emergency conditions cultures were not made. The patient made an uneventful recovery.

Comment. Case II represents an earlier stage of the disease than Case I.

# SUMMARY

The roentgen characteristics of emphysematous cholecystitis are specific and usually the diagnosis can be established by plain roentgenograms. Two new cases here reported illustrate the typical roentgen findings. The sequence of events is simi-

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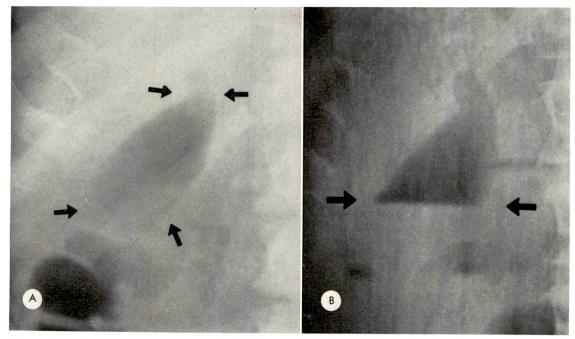


Fig. 4. Emphysematous cholecystitis. (A) Pear-shaped radiolucency in right upper quadrant with tapered upper margin characteristic of neck of gallbladder. (B) Erect roentgenogram showing fluid level (arrows) outlined by gas in the upper half of gallbladder.

lar to that demonstrated by Heifetz and Wyloge in experimental distention of the gallbladder.

The significant conditions to be considered in differential diagnosis are (1) gas in the gastrointestinal tract; (2) biliary gastrointestinal fistula, or incompetent sphincter of Oddi; (3) extrabiliary subhepatic abscess (including appendiceal); and (4) poor mixing of the bile and opaque material during intravenous cholecystography.

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# CALCIFICATION OF THE GALLBLADDER ("PORCELAIN GALLBLADDER")\*

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ALTHOUGH diseases of the gallbladder are of great importance to the diagnostic roentgenologist, surprisingly little information about calcification of the gallbladder has appeared in the radiologic literature. It seemed desirable, therefore, to collect some observations about the subject from the medical literature and to analyze 9 cases diagnosed at the Ochsner Clinic.

#### HISTORICAL NOTES

Calcification in the wall of the gall-bladder has probably occurred since ancient times, although the date of the first medical report about it is uncertain. Buckstein<sup>4</sup> credited Fabre of France with recording in 1831 a case encountered at necropsy. In English medical literature, the earliest report seems to have been that of Allison<sup>1</sup> in 1845, the abnormality in his case also having been a postmortem discovery.

Until the advent of successful abdominal surgery late in the nineteenth century, however, lesions of the gallbladder were chiefly of academic interest. Even when surgical treatment became available, preoperative diagnosis of most cholecystic diseases was largely conjectural until the enlightening development of diagnostic roentgenology in the early twentieth century. In 1909, Phélip and Maisons<sup>18</sup> reported a case of a large calcified gallbladder that was seen on a preoperative roentgenogram, but unfortunately the roentgenogram was not reproduced in the report. The next case was recorded in 1923, when Fowler, operating for what was considered preoperatively to be a large gallstone, resected a gallbladder containing extensive calcification in its wall and many stones in its lumen. He stated that some eminent radiologists (Pfahler, Crane, and Pancoast) reported they had never seen a similar case.

Sporadic case reports have appeared since then. 8,11,19 Hubeny and co-workers 10 recorded 3 proved cases and discussed the roentgenologic diagnosis in some detail. They recommended multiple roentgenograms including some made in oblique and lateral projections, as well as in different phases of respiration. In 2 other cases, operation disclosed no calcification of the gallbladder, as diagnosed preoperatively. As alternate diagnostic possibilities in the presence of calcification in the right upper abdominal quadrant, they mentioned urinary calculi, hepatic calcification, and calcification in costal cartilages.

#### **PATHOGENESIS**

The ultimate cause of calcification in the wall of the gallbladder is not known. Summarizing the usual etiologic theories, Feldman<sup>7</sup> listed low grade inflammation, intramural hemorrhage or extravasation of blood, imbalance in calcium metabolism, and irritation from foreign body or trauma. None of these factors satisfactorily explains all cases. Phemister and co-workers, 14,15 among others, 2,5,8,12,17 stressed particularly the importance of chronic obstruction of the cystic duct, subsequent to which calcium carbonate in large quantity is said to pass from the wall of the gallbladder into the lumen. In this way, they postulated, there may occur calcification in the wall as well as increase of calcium salts in the luminal contents. Kettunen<sup>11</sup> pointed out the frequent association of gallstones. More recently, Samuel and Komins<sup>18</sup> have postulated that localized calcification in the gall-

<sup>\*</sup> From the Department of Radiology, Ochsner Clinic, and Department of Pathology, Ochsner Foundation Hospital, New Orleans, Louisians.

bladder could result from calcification of cholesterol plaques.

#### PATHOLOGIC OBSERVATIONS

A study of the resected gallbladder is particularly interesting if the histologic alterations are considered in conjunction with the roentgenographic appearance. In our cases we observed two quite different types of calcification in the wall of the gallbladder.

In one type, the microscopic appearance consists of a strip of calcification in the muscular coat of the wall of the gallbladder (Fig. 1A). This extends lengthwise in relation to the wall and, grossly, appears as flakes or plaques of varying size. Roentgenographic study of the resected specimen (Fig. 1B) shows these calcific structures in the wall of the gallbladder. These adequately account for the appearance of the gallbladder in the preoperative cholecystogram (Fig. 1C).

In the second type, there are multiple small calculi, or microliths, in the glandular spaces of the mucosa and in the Rokitansky-Aschoff sinuses (Fig. 2A). These microliths are round or oval and are scattered diffusely in the mucosa and submucosa; some may be found in the muscularis and may be associated in some areas with strips of calcification in the muscular coat. Grossly, the mucosa is partially denuded and the surface is granular, resembling sandpaper. Roentgenographic study of the resected specimen (Fig. 2B) shows both the granular and plaque types of calcification in this gallbladder. Also revealed in this instance is a large calcified gallstone occluding the outlet of the gallbladder. The preoperative cholecystogram (Fig. 2C) is particularly interesting, as it reveals the obstructing stone, an area of stenosis in the body of the gallbladder, a pasty type of

calcium bile, and the calcification in the wall of the distal portion of the gallbladder. This case, therefore, is a clear example of the similar pathologic background, stressed by Phemister and co-workers, <sup>14,15</sup> of milk of calcium bile and calcification in the wall of the gallbladder.

Thickening of the wall from chronic inflammation is the general rule. The mucosa may be denuded or may exhibit evidence of chronic inflammation. Brown<sup>3</sup> reported a case in which carcinomatous change had occurred.

#### ROENTGEN DIAGNOSIS

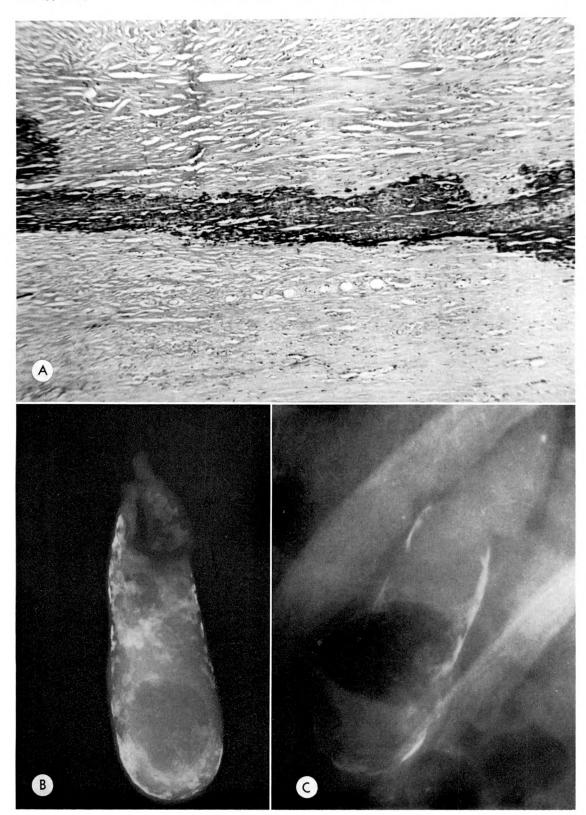
Plain roentgenograms made in posteroanterior and oblique projections are basic views in cholecystographic study. Proper exposure and processing are necessary to obtain films of highest quality. If a calcified gallbladder is suspected after routine examination, roentgenograms in exaggerated oblique views and others made in full inspiration and expiration may then be obtained. This prevents confusing a gallbladder with calcified costal cartilages.

Other special roentgenologic techniques are available if doubt remains. Stereoscopic roentgenograms or laminagrams should certainly allow a gallbladder of any size, shape, or location to be separated from superimposed or mimicking structures of the skeleton.

Examination with various contrast media helps to exclude various other possible diagnoses. Urographic studies visualize the renal structures and prevent misdiagnosis of renal cyst, aneurysm, or calculi. Outlining segments of the alimentary tract by barium studies should aid in localizing precisely the calcified shadow if doubt still remains about its biliary nature. Cholecystography is generally undertaken but usually proves of limited value because there is

**⋙→** 

Fig. 1.(A) Photomicrograph of the muscular coat of gallbladder, showing a continuous layer of calcified tissue in the mid-portion of the muscularis. In this case, the mucosa had totally desquamated and the lumen was lined with hyalinized fibrous tissue (H. & E. enlarged 160×). (B) Roentgenogram of resected gallbladder. (C) Preoperative cholecystogram shows calcified outline of gallbladder.



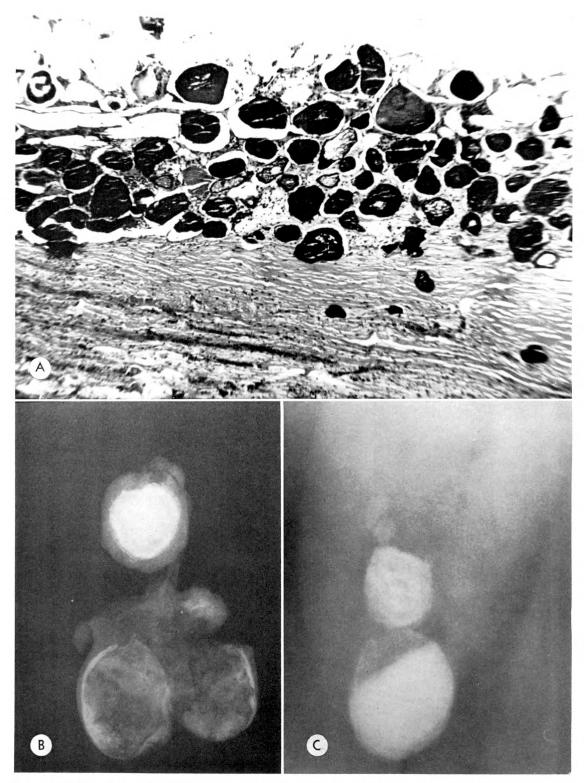


Fig. 2.(A) Photomicrograph of the mucosa, submucosa, and part of the muscularis. Each glandular space is occupied by a microlith. The epithelium has become denuded. The stroma shows mild chronic inflammation. Some microliths are present in the submucosa and in the muscularis (H. & E. enlarged 160×).

(B) Roentgenogram of opened gallbladder after resection shows granular and plaque-like calcification in distal portion. Large calcified stone occludes proximal portion. (C) Preoperative cholecystogram reveals a gallbladder with mid-section stenosis, a stone filling the proximal segment, calcification in the wall, and milk of calcium bile in the distal segment.

little or no concentration of the medium by the gallbladder. Intravenous cholangingraphy might have occasional usefulness in relating the calcified shadow to the biliary ducts. The appearance of calcification in the wall of the gallbladder is distinctive. Linear, flaky, or plaque-like calcifications are present in the expected position of the gallbladder (Fig. 1C and 2C). Because of the globular or pear shape, the appearance may immediately suggest the possibility of a gallbladder outlined by calcification in its wall (Fig. 3). In 2 of our cases, the calcified gallbladder had a double contour (Fig. 4). Visualization in various projections confirms the location that is consistent with that of the gallbladder, and any additional roentgenologic procedures reconfirm the diagnosis by eliminating other possibilities.

Costal cartilages lie anteriorly, generally do not calcify in such a way as to mimic the complete outline of a gallbladder, and can be differentiated from the gallbladder by roentgenograms made in various projections and in different phases of respiration. A large gallstone may be confusing but



Fig. 3. Calcification in the wall of a large globular gallbladder.



Fig. 4. Double contour type calcification in the wall of a gallbladder.

generally shows laminated rings of calcification, an oval rather than pear shape, and a solid rather than plaque-like margin. Hepatic calcification may be punctate, granular, or quite large and dense, but rarely mimics closely the configuration of a gallbladder or the type of calcifications occurring in walls of a sac-like structure such as the gallbladder.

Calcification in renal lesions lies posteriorly, cannot be separated from the kidney, and should be properly localized with the aid of urographic procedures. Calcified cysts or tumors of adrenal origin also lie posteriorly, maintain a relationship with the upper pole of the kidney, and should rarely be confused with cholecystic calcification. Calcareous lymph nodes are usually smaller, have a coarse granular appearance, and do not readily assume the appearance or location of a calcified gallbladder. Calcification in a mesenteric cyst is a rare and unlikely source of confusion. An abdominal abscess or hematoma may occasionally exhibit some calcification but is not apt to mimic a gallbladder in shape or location. Vascular calcification, especially in an aneurysm, can mimic the type of calcifica-

Patient	ı	2	3	4	5	6	7	8	9
Age	48	62	5 <b>4</b>	62	42	59	81	52	45
Color and Sex	W M	WF	WF	N F	W M	WF	WF	WF	WF
Duration of Complaints (yr.)	neresta.	2	25	3	2	40		5	7
Symptoms									
Gas				+	+	+			
Indigestion	-	+		÷	÷	+	-	*****	+
Epigastric Pain	*****		+	+	_	-		+	
Right Upper Quadrant Pain		+		<u>.</u>	+	+	******	******	
Fat Intolerance			+	_	<del>-</del>	+		*******	
Nausea	-	-	<u>-</u>	_	+	<u>.</u>	********	******	+
Signs					,				
Mass	+			_		+	****		
Tenderness	-		-	_	_	+			
Jaundice			_	_	_		-	****	
Cholecystographic Findings		-							
Calcified Gallbladder	+	+	+	+	+	+	+	+	+ double
Size	large	average	stenotic	average	small	large	average	average	contour
Function	none		none	none	none	none	none	none	none
Gallstones	5		+	-	3	3		5	
Cholecystectomy	0	0	+	0	+	+	0	0	0
Pathologic Study					A				
Cholecystitis			+		+	+			
Calculi			+			+			
Calcified Gallbladder			+		+	+			
Cystic Duct Obstructed			+			+			

tion seen in the wall of the gallbladder, but for practical purposes aneurysms in the cholecystic area are nonexistent.

#### DISCUSSION OF PERSONAL CASES

The pertinent data about the 9 cases observed at the Ochsner Clinic are summarized in Table 1. It is interesting that 7 of the 9 were women and that symptoms suggesting biliary disease were often absent. Robb16 described the remarkable paucity of symptoms in these striking words: "... the calcified gallbladder is most often so quiescent in its development, so unproductive of symptoms, that the existence of many must never be known or even suspected, and they are cast upon the rubbish heap of treasures whose only signpost is senile decay." This asymptomatic organ may, however, be enlarged or palpable as a firm mass in the right upper abdominal quadrant.

The roentgenographic observations in all our cases were decisive. Medical treatment was undertaken in 6 of them, because surgical removal was refused or deemed inadvisable due to some surgical contraindication. Three patients had cholecystectomies. The cystic duct was described as "occluded" in 2 and not mentioned in the other. In one instance there was a granular, pasty type of milk of calcium bile in the distal portion of a gallbladder, which had stenosis of its middle section.

# COMMENT

Calcification of the wall of the gallbladder is relatively rare. As this tends to appear after the age of 45 years, it seems inevitable that radiologists will encounter it with increased frequency. It is evidence of chronic disease of the gallbladder and has to be evaluated in that sense.

The problem of clinical management is

unsettled. Whether it is necessary to operate on the asymptomatic patient is a question that involves medical philosophy as well as individual medical features in any single patient. Not enough cases have been studied to be dogmatic about the decision. In the symptomatic case, removal of the chronically diseased gallbladder is amply justified. In our 3 patients subjected to cholecystectomy, clinical improvement was notable. If no medical contraindication exists, cholecystectomy seems indicated.

#### SUMMARY

The pertinent data in 9 cases of calcification of the gallbladder have been discussed. The paucity of symptoms is surprising. Pathogenesis of the lesion is uncertain, but obstruction of the cystic duct and chronic inflammation are constantly associated. Histologically, two types of calcification have been found in the wall of the gallbladder—strips and plaques of calcium in the muscular coat, and multiple microliths in the mucosa and submucosal tissues. Roentgenographic demonstration of calcification of the gallbladder is striking and diagnostic, but must be carefully differentiated from other types of calcified lesions in the right upper abdominal quadrant. Unless medically contraindicated, cholecystectomy is recommended, especially in the symptomatic case.

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#### ORAL CHOLECYSTANGIOGRAPHY\*

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THIS brief communication presents and illustrates the advantages of a technique for biliary tract examination which, though introduced in Europe, has not yet received widespread attention in America.

In any instance where good gallbladder visualization results from the use of an oral cholecystographic agent, equally good visualization of the cystic and common ducts requires only the appropriate redistribution of the contrast agent already present in the gallbladder. Contraction of the gallbladder is the purpose of the usual "fat meal" given in conventional cholecystography and, to the extent it is effective, this assists in visualizing biliary ducts. Probably the most potent means of causing prompt and effective gallbladder contraction is the intravenous administration of cholecystokinin. The use of a commercially available preparation of this hormone permits consistent and striking improvement in the ductal visualization associated with conventional cholecystography. A description of the technique we have employed follows.

#### TECHNIQUE

#### PREPARATION OF PATIENT

A low residue or fluid diet is given the day before the examination. Castor oil with or without contact laxative enemas or suppositories is used to minimize the presence of gas in the gastrointestinal tract. The usual dose of a conventional oral cholecystographic agent is given the evening prior to examination. We have found bilopaque preferable, although orabilex, telepaque and biloptin would probably prove satisfactory.

#### PRELIMINARY EXAMINATION

On the morning of study, conventional roentgenograms of the gallbladder are

made and inspected to determine the adequacy of gallbladder opacification and, in suitable cases, the optimum projection for subsequent studies. No "fat meal" is given.

With the roentgenographic table tilted to the 30° Trendelenburg position, a control film is exposed in a right posterior oblique projection, chosen to project the gallbladder and common duct anterior to the spine (Fig. 1). Following inspection of this film and any indicated adjustment in the degree of obliquity, the position is retained during the 20 minutes required to complete the study.

## INJECTION OF CHOLECYSTOKININ, AND ROENTGENOGRAPHY

Cholecystokinin is commercially available\* in individual dose ampules of white, crystalline powder with the biological activity of 75 Ivy units. Dissolved in 2 or 3 cc. of sterile distilled water, this is injected intravenously in 2 to 3 minutes. More rapid injection of the hormone may cause premature contraction of the gallbladder infundibulum, hampering emptying and sometimes resulting in right upper quadrant pain or discomfort. Films are exposed at suitable intervals following the injection, for example at 3, 6, 9, 12 and 15 minutes. Care should be taken to prevent the patient from sliding out of position during this period. Shoulder supports, hand grips, and ankle straps may aid in this effort to insure the desired redistribution of contrast agent within the biliary tract. Relatively low kilovoltage and high milliamperage are used to favor roentgenographic contrast; scatter is combatted through the use of a high-ratio (16:1) grid and a small (sinus) cone.

\* Cholecystokinin under the trade name of Cecekin is obtainable from Vitrum, Box 12170, Stockholm 12, Sweden, at a cost of \$3.00 per individual dose ampule.

<sup>\*</sup> Presented at the Pacific Northwest Radiological Society Meeting, Seattle, Washington, May, 1962.
† Research Fellow, Department of Radiology, University of Oregon Medical School, October, 1961–1962.

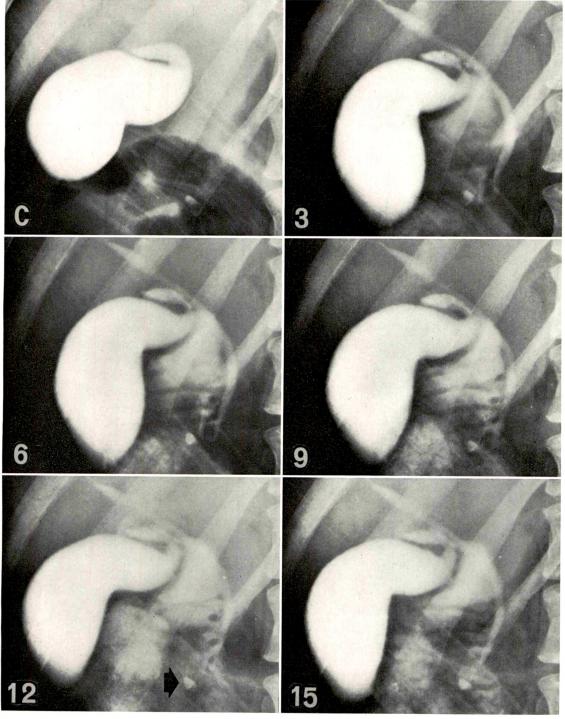


Fig. 1. Normal oral cholecystangiography. Female, aged 40 years. Right posterior oblique projection, 30° Trendelenburg. (C) Control cholecystangiogram exposed about 12 hours after oral administration of 6 gm. of bilopaque. Remaining five films exposed at indicated time (minutes) following intravenous injection of 75 Ivy units of cholecystokinin show sustained opacification of normal central biliary ducts and progressive passage of agent into the duodenum. A small calcific density projected near the sphincter of Oddi (arrow) is anterior and unrelated to the duodenum.

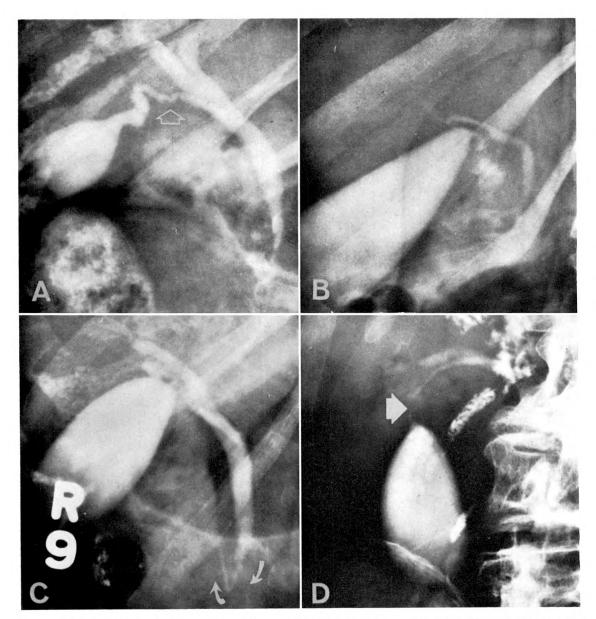


Fig. 2. Oral cholecystangiography in four different patients. (A) Female, aged 50 years. Normal appearance 9 minutes following administration of cholecystokinin. Arrow points to spiral valve of Heister. Narrowing of common duct at sphincter of Oddi is normal. (B) Female, aged 49 years. A much larger gallbladder and somewhat narrowed cystic duct at 12 minutes after injection of hormone. (C) Female, aged 40 years. Nine minute cholecystangiogram showing stream of bilopaque entering and running proximally within duodenum (arrows). Direction of flow results from steep Trendelenburg position employed. (D) Female, aged 53 years, cholelithiasis. Head-down projection evidently caused small stones to impact in neck of gallbladder. A stone or regional spasm has narrowed the cystic duct (arrow), resulting in incomplete visualization of the common duct. In A, C and D there is definite filling of hepatic ducts, an objective of the Trendelenburg position.

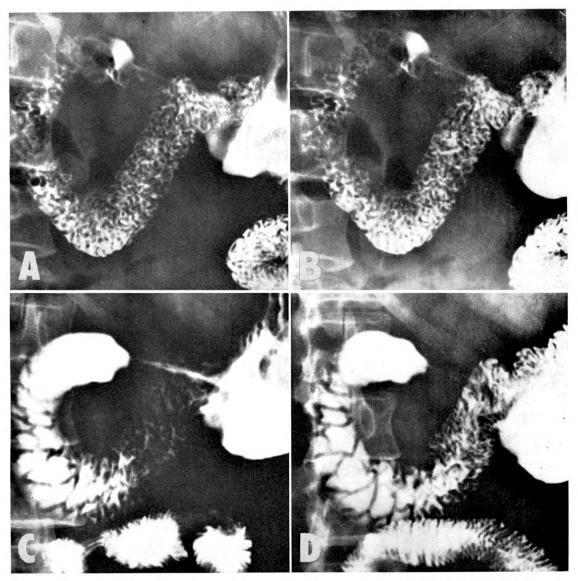


Fig. 3. Effect of cholecystokinin on duodenal mucosa. Female, aged 66 years. No cholecystographic agent given. (A and B) Control views of normal duodenum. (C and D) Coarsened duodenal mucosal pattern 10–12 minutes following cholecystokinin injection. Variations in the gastrointestinal response to cholecystokinin may be of diagnostic value.

#### DISCUSSION

Results regularly obtainable through cholecystokinin-induced gallbladder contraction are illustrated in Figures 1 and 2,A-D. The expulsive effort of the gallbladder is often effective enough to result in useful visualization of the duodenum. Cholecystokinin causes prompt relaxation of the peristaltic activity normally present in the stomach and proximal small bowel

and a marked change in their roentgenographic appearance usually results (Fig. 3,A-D). Such changes are reported to be of value in roentgenologic studies of the gastrointestinal tract,<sup>4</sup> and would appear to be of particular interest in connection with mechanical lesions of the duodenum and functional abnormalities of the small bowel. Although apparently hazard-free, the effort to obtain cholecystokinin-medi-

ated visualization of the cystic, common and hepatic ducts can only succeed if the gallbladder contains and is capable of expelling sufficient radiopaque fluid to cause the desired result. Thus, unfortunately, the technique offers little to the study of patients who, because of gallbladder disease, are most likely to benefit from preoperative examination of their biliary ducts. We know of no reported effort to employ cholecystokinin in connection with direct inspection of the gallbladder during surgery or during operative, postoperative or intravenous cholangiography; all appear to be areas of promise. Despite the foregoing limitations, under appropriate circumstances the technique offers a useful and striking improvement in the roentgen study of biliary tract disease and function.

The cost of cholecystokinin is relatively minor compared to the cost of a second study and virtually insignificant if weighed against that of cholecystectomy. Nevertheless, against the pronounced advantages of its appropriate use in biliary tract examination must be balanced the considerable increase in time required for the conduct of the study. The technique is *not* suitable for

assembly-line radiologic practice. A discussion of the extent to which economic factors influence the practice of radiology is beyond the intent of this report.

#### SUMMARY

Probably the most potent means of producing effective gallbladder contractions in oral cholecystoangiography is the intravenous administration of cholecystokinin.

The technique, advantages and limitations of this procedure are described.

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## A COMPARATIVE EVALUATION OF A NEW ORAL CHOLECYSTOGRAPHIC AGENT BILOPAQUE WITH ORABILEX\*

By M. P. JUDKINS, M.D., P. E. BILLIMORIA, M.D., and C. T. DOTTER, M.D. PORTLAND, OREGON AND BOMBAY, INDIA

RADIOLOGY has always played an important role in the accurate diagnosis of biliary tract disease. Since the introduction of the Graham-Cole test in 1924, biochemists, clinicians, surgeons, and radiologists persistently have attempted to improve the diagnostic accuracy of both oral and intravenous examinations of the biliary system. The advent of telepaque\* in 1951 made possible further progress in oral cholecystography and cholangiography.<sup>3,14,16</sup> A high standard of diagnostic accuracy was set with telepaque. Baker and Hodgson<sup>1</sup> report 98 per cent correlation between roentgenologic and surgical-pathologic findings in 1,207 telepaque studies. During the last few years, a number of new contrast agents including orabilex,† oragrafin‡ and bilopaque have been developed. To warrant acceptance, a new agent should exhibit reduced toxicity and side effects, and at the same time meet or improve on the diagnostic accuracy previously possible. Although side effects with telepaque are not serious, they may at times be annoying. The drug has had an envious safety record and for several years has constituted a standard for comparison.

Biochemical interest has centered on increasing the solubility of cholecystographic media and on manipulating their side chains to increase absorption, reduce side effects, and alter routes of excretion. Oragrafin, orabilex, and bilopaque are products

\* Telepaque (brand of iopanoic acid), Winthrop Laboratories, New York, New York.

† Orabilex (brand of bunamiodyl sodium), supplied by E. Fougera and Co., Hicksville, New York.

‡Oragrafin (brand of ipodate sodium), E. R. Squibb and Sons, New York, New York.

§ Bilopaque (brand of sodium tyropanoate), supplied by Winthrop Laboratories, New York, New York.

of such research. Recently, orabilex has received considerable attention from in vestigators in the United States. Certain reports<sup>6,10–13,15,17</sup> have indicated that its use is associated with a reduction in side effects without sacrifice of diagnostic effectiveness.

#### BILOPAQUE, A NEW AGENT

This is a comparative study of orabilex, 3(3-butyrylamino-2,4,6-triiodophenyl)-2-ethyl sodium acrylate, and bilopaque, sodium 2-(3-butyramido-2,4,6-triiodobenzyl)butanoate. Similarities and variations of the structural formulas of telepaque, oragrafin, orabilex, and bilopaque are graphically shown in Figure 1.

Bilopaque (Win 8851-2) was synthesized by Ackerman and found on the basis of animal studies by Hoppe to offer promise as a superior oral cholecystographic contrast medium. Comparative cat oral cholecystographic studies indicate that bilopaque is about 40 per cent more effective than telepaque or orabilex. Given intravenously to

Fig. 1

<sup>\*</sup> From the Department of Radiology, University of Oregon Medical School Hospitals and Clinics, Portland, Oregon.

rats, bilopaque was found to be less toxic than either sodium telepaque or orabilex. The intravenous LD<sub>60</sub> mouse dose is 655 mg./kg.; this compares with 418 mg./kg. for orabilex. The biochemical and toxicologic data on bilopaque indicate that the compound is not likely to produce untoward reactions in the anticipated clinical dose range of 50 mg./kg. or less.8 Bilopaque is rapidly absorbed from the intestinal tract with peak blood level attained in I to 4 hours. Its excretion is divided between urine and feces in a ratio of I to I; this compares with similar ratios for telepaque of 0.6:1 and for orabilex of 2:1.13 Serum iodine levels are just detectably above control values in 72 hours.9 This laboratory information suggested that bilopaque might be superior to cholecystographic media currently in use and led to this clinical appraisal.

#### METHOD OF STUDY

In the comparison of two contrast agents, the undesirable effects of observer subjectivity are minimized through the proper application of so-called "blindfold" techniques. Statistical validity will also be favored if comparisons are based upon groups of patients of similar age, weight, sex, incidence of pathologic findings, etc. With this in mind, a "cross-over" comparison study was done. In this study, each patient was examined first with one agent and then with the other under blind conditions

The study was performed with consecutive outpatients referred to the Radiology Department of the University of Oregon Medical School Hospitals and Clinics for oral cholecystography. Each patient had two separate routine oral cholecystographies performed. A 7 day interval was used.

Thus, each set of films compared were those of a patient of the same age, sex, weight, and physical condition (himself), eliminating, as far as possible, variables of absorption, hepatocellular function, ability to concentrate and numerous other factors

not as readily controlled by alternate or random case selection methods. Orabilex and bilopaque, the two agents to be compared, were administered in alternating order to reduce the possibility, however unlikely, of the first examination influencing the succeeding one.

A remaining variable in this study is the patient's changing physical status—deterioration or improvement. The short time interval between studies, the reasonably stable condition of outpatients, and the alternation of agents reduced this factor to negligible proportions.

Coded film evaluation consisted of a simple comparison of the two examinations on the basis of equality or superiority of visualization. Independent review by 3 radiologists further reduced subjectivity.

This series comprised 180 consecutive patients (360 cholecystographic studies). For the initial examination, orabilex was given to 92 patients and bilopaque to 88 patients. All patients received 4.5 gm. of orabilex. Because of the experimental status of bilopaque, a dose of only 3 gm. was given to the first 71 patients. The succeeding 109 patients received the presently recommended dose of 4.5 gm. Patient age ranged from 14 to 84 and averaged 53 years.

#### VISUALIZATION

Table I and II show the assessment of visualization of the two agents. In 29 cases (16 per cent of the entire group) stones were seen, in all instances with both agents.

There were 16 instances (9 per cent) of

Table I
ASSESSMENT OF VISUALIZATION

	71 Cases			
	Gallbladder		Common Duct	
	Equal	Better	Equal	Better
Orabilex 4.5 gm.		7	56	9
Bilopaque 3 gm.	57	7		6

TABLE II
ASSESSMENT OF VISUALIZATION

	109 Cases			
-	Gallbladder		Common Duct	
	Equal	Better	Equal	Better
Orabilex 4.5 gm.	88	IO	79	9
Bilopaque 4.5 gm.	00	ΙΙ	79	21

"nonfunction" regardless of the drug used. In one of these, a second dose of bilopaque, given 24 hours after the regular dose, led to visualization the following day. In a separate instance of initial nonvisualization with bilopaque, administration of orabilex resulted in visualization a week later. In 2 patients of the "nonfunctioning" group, common duct visualization was obtained with both agents without the use of special roentgenographic procedures.

There was little difference in the diagnostic quality of the gallbladder shadow produced by either the 3 gm. or the 4.5 gm. dose of bilopaque. When equal doses were used (the standard 4.5 gm. dose), the common duct was demonstrated to better advantage in 21 patients given bilopaque and in 9 patients given orabilex.

#### SIDE EFFECTS

Each patient was interviewed prior to each examination and detailed records kept of pertinent data. Attention was directed to (1) the existence of and nature of symptoms of the present illness, (2) the effect of a routinely given preliminary (pre-study) fat meal and, (3) the symptoms following, and believed related to, the ingestion of the contrast media.

Before they were referred for examination, many patients, most of whom were suspected of having gallbladder disease, had symptoms such as nausea (45 per cent), vomiting (26 per cent), diarrhea (19 per cent), dysuria (15 per cent), urticaria (10 per cent), etc., associated with their present

illness. This high frequency of symptoms occurring prior to the ingestion of cholecystographic agents makes it difficult to distinguish between symptoms of the present illness and side effects of contrast media. It appeared possible, however, to differentiate between existing symptoms and aggravated symptoms. Since only 15 per cent of the patients without prior nausea experienced it following ingestion of a contrast agent, the incidence of nausea in the over-all series can properly be regarded as the aggravation of an existing symptom. All asymptomatic patients experiencing nausea (the 15 per cent) did so after the ingestion of orabilex. There was no correlation between those experiencing symptoms attributable to the contrast agents and those experiencing symptoms from the fat meals. Many did not have symptoms from both fat meals. The lowest incidence of side effects encountered (4 per cent) was in the 45 patients exhibiting stones or "nonfunction." History of allergy did not relate to reactions.

In the course of the present study a single instance of moderately severe hives followed orabilex administration but did not recur with the ingestion of bilopaque I week later. The absence of hives with bilopaque tends to discount iodine sensitivity (the reaction may have been related to side chain structure). Another patient developed a fine red rash following the ingestion of orabilex without having a similar reaction to bilopaque. Similar skin reactions have been reported by Cornelius *et al.*<sup>5</sup>

Oral cholecystography with either bilopaque or orabilex produced fewer annoying side effects than did a simple fat meal in this series. While in our experience no serious reaction has occurred with the use of either agent, severe allergic reactions and renal failure are reported following the use of orabilex.<sup>4,5,7</sup> Bilopaque has only recently become available.

The study shows a 35 per cent lower incidence of side effects following administration of bilopaque than following adminis-

TABLE III
INCIDENCE OF SIDE EFFECTS

	Pre-Examination Fat Meal	Orabilex 4.5 gm.	Bilopaque 4.5 gm.	Bilopaque 3 gm.	PC Neocolex
Nausea	26%	16%	10%	3%	19%
Vomiting	2%	0	0	0	1%
Diarrhea	2% 2%	$_{1}\%$	0	0	1% 1% 1%
Cramping	3%	o T	0	0	1%
Frequency	0	$_{ m I}\%$	$_1\%$	0	1%
Urticaria	0	I case hives I case red rash	0	0	
Total		18%	11%	3%	· · · · · · · · · · · · · · · · · · ·

Recorded to the nearest per cent.

tration of orabilex. The incidence of nausea with orabilex (16 per cent), 5,10,11,13,16 and with bilopaque (10 per cent)<sup>2</sup> is similar to that reported by other investigators (Table III).

#### DISCUSSION

Bilopaque and orabilex are similar in structure and iodine content (57 per cent). Any visualization advantage that one may have over the other presumably involves either (1) increased absorption or (2) increased hepatobiliary excretion over that of renal excretion or both. Clinical evaluation of gallbladder or common duct density in this "cross-over" study is an appraisal of these factors.

Common duct visualization is dependent upon (1) hepatobiliary concentration of the agent and (2) response of the gallbladder to the fat meal. Variations in density of the biliary system can be readily appreciated when the ductal structure is evaluated. On this basis, bilopaque demonstrates a somewhat higher degree of opacification. Implications that a so-called "optimal" (submaximal) degree of density and a higher degree of common duct visualization can be obtained with the same agent are inconsistent. If ductal visualization is desired, maximal opacification of the gallbladder is necessary. Excessive opacification of the gallbladder presents no problem if an appropriate roentgenographic contrast scale is used.

Minor changes in the side chains of basic organic compounds may markedly alter toxicity and modes of excretion. In this study, bilopaque, a product of such a change, shows a significant decrease in sideeffect toxicity. Eventual total excretion is equally divided between urine and feces. Some investigators have suggested that renal excretion is to be preferred to that of intestinal elimination. The lower renal excretion rate of bilopaque compared with orabilex may prove to be an advantage in that fewer cases of renal failure may result from its use. Assuming that the bowel is a less critical route of excretion, a "soluble" agent with an even higher ratio of bowel excretion might be sought. Bowel opacification from both agents was minimal; seldom did this interfere with diagnostic quality more than did the presence of normal bowel content.

#### SUMMARY

- 1. Bilopaque and orabilex were subjected to blind "cross-over" comparison, a method which has the advantage of comparing both agents in the same patient under the same conditions.
- 2. The common duct was visualized to better advantage twice as often with bilopaque.
- 3. Nausea was the most commonly encountered side effect—10 per cent with bilopaque and 16 per cent with orabilex.

Two patients exhibited skin reactions following orabilex.

- 4. It has been stated that renal excretion is to be preferred over intestinal elimination. We believe that the opposite point of view merits serious consideration.
- 5. Both agents are effective cholecystographic media. Bilopaque merits consideration as the agent of choice on the basis of a lower incidence of side effect, toxicity, and excellence of visualization.

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#### CHOLANGIOGRAPHY AND BILIARY ENDOSCOPY AS COMPLEMENTARY METHODS OF EVALUATING THE BILE DUCTS\*

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HE treatment of disorders of the biliary tract depends upon the correct diagnosis of the responsible etiologic factors. In this effort the radiologist is called upon to demonstrate the presence and the cause of obstructive choledochopathy. A surgical adjunct to cholangiography has been introduced with choledochoscopy which permits direct visualization of the lumen of the bile ducts. The choledochoscope, in its present form, was devised by Wildegans<sup>12</sup> in 1953. Instrumentation of the common bile duct by direct visualization goes back over a period of 30 years. The experiences of Antonucci and McIver are of historical interest. The Wildegans choledochoscope (Fig. 1) is essentially a biliary tract sound with a lens and irrigating system that enable the surgeon to visualize the interior of the biliary tree. The choledochoscope is introduced into the common bile duct at the time of surgery through a choledochotomy incision. The instrument allows the surgeon to view directly ahead beyond the point of insertion. The image may be magnified as much as 2 to 4 times. The true image size is obtained when the lens is approximately 2.5 cm. away from the object. Further developments in choledochoscopy are imminent with replacement of the rigid instrument by a flexible one, incorporating the principle of fiber-optics. The present rigid choledochoscope can be sterilized by the techniques that are ordinarily applied to cystoscopic instruments.

PREOPERATIVE, OPERATIVE, AND POSTOPERATIVE CHOLANGIOGRAPHY

The methods of preoperative evaluation of the common bile duct and its major

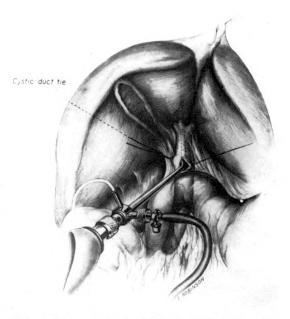
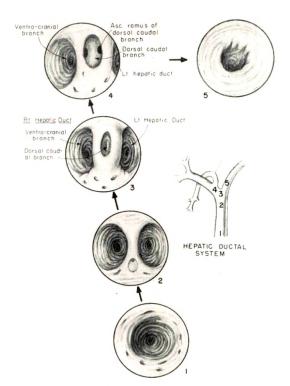


Fig. 1. The technique of biliary endoscopy as performed at the time of choledochotomy. The site of battery connection and saline hose attachment to the choledochoscope are shown. The lens of instrument is manipulated within the common duct and its branches.

tributaries are well known to the radiologist. These methods consist of oral, delayed oral, intravenous and transhepatic percutaneous cholangiography.1 Operative cholangiography was introduced by Mirizzi<sup>6</sup> in 1932 and has justifiably gained widespread acceptance. Operative or postoperative cholangiography may be carried out by (1) opacification of the biliary tree via the gallbladder through a cholecystostomy tube; (2) introduction of opaque medium into the common duct via the cystic duct stump during the operative procedure thus avoiding a choledochotomy; (3) direct puncture of the common bile duct during the surgical procedure; and (4)

<sup>\*</sup> From the Division of Diagnostic Radiology and the Division of Surgery, Montefiore Hospital, New York, New York, Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 2–5, 1962.



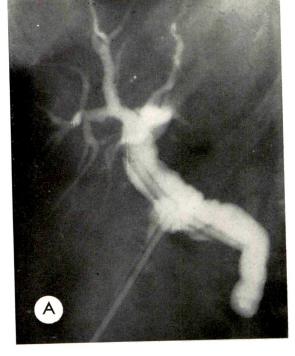


Fig. 2. An artist's drawing of the endoscopic appearance of the lumen of the hepatic ductal system, as obtained by direct observation and cinematographic documentation. The schema of the hepatic ductal system on the right indicates the position of the lens and the area visible to the endoscopist. (1) The common hepatic duct is viewed looking toward the carina. Numerous pitted glandulae mucosae are well demonstrated. The common hepatic duct appears as a mucous membrane-lined cylinder. (2) The carina marks the division between the major hepatic ducts. An accessory duct may be noted in the posterior portion of the spur. Mucous membrane details are easily discerned. (3) As the choledochoscope is advanced and moved from side to side, the bifurcation of the right hepatic duct comes into view. At this site the "trifurcation" is most clearly defined. (4) At the ostium of the right hepatic duct, the ventrocranial division is seen as a straight tube. The dorsocaudal division is visualized for 1 to 2 cm. to the site of its division. (5) The tubular left hepatic duct appears as a cylindrical structure. (From Schein, Stern and Jacobson<sup>9</sup>)

B

Fig. 3. Case I. (A) Cholangiogram showing an obstruction at the distal end of the common duct with moderate dilatation of the latter. (B) Choledochoscopy revealed marked edema of the papilla

use of the indwelling T-Tube as the avenue of injection.

In a previous report<sup>9</sup> we have presented the normal anatomy of the hepatic ductal system from the endoscopic and roentgenographic viewpoints (Fig. 2). The significance of the lateral view in T-tube cholangiography was emphasized.<sup>11</sup> The common normal variations in the right and

of Vater.

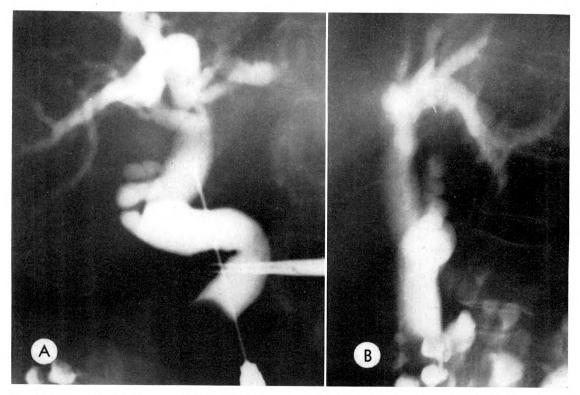


Fig. 4. Case II. Percutaneous transhepatic cholangiograms. (A) Spot roentgenogram in a frontal projection shows a dilated common duct, with a sharply circumscribed radiolucent defect in its distal end. No contrast medium is seen in the duodenum. Choledochoscopy confirmed the presence of a large calculus in the distal common duct. Note a typical cystic duct stump. (B) Lateral projection of same study. The cystic duct stump is clearly seen posterior to the dilated common duct. Residual barium is present in diverticula of the large bowel from a previous barium enema examination.

left hepatic ducts and their branches were described. The normal and pathologic endoscopic findings were documented by still photography and cinematography.

#### CLINICAL MATERIAL

A series of 54 choledochoscopies have been performed. Most of these patients have had concomitant operative and post-operative cholangiography. In 8 of these choledochoscopic examinations significant help has been obtained by consideration of the findings of the combined methods. This has resulted in the clear demonstration of the exact etiologic factor and the precise indication for surgery. Such information could not have been obtained by either method alone. These 8 cases are briefly documented.

#### ILLUSTRATIVE CASES

CASE I. Edema of the Papilla with Failure of Contrast Medium to Enter the Duodenum. A 64 year old diabetic woman with a long history of biliary colic and dyspepsia was operated upon after several episodes of intermittent jaundice. At operation the gallbladder was found to contain many small calculi; the cystic duct was patent. The common bile duct measured 1.6 cm. in width, and contained "mud" and many small stones. An operative cholangiogram showed a dilated common duct, but the contrast agent did not readily pass into the duodenum (Fig. 3A). A repeat operative cholangiogram, 20 minutes later, again failed to demonstrate patency of the common duct. The terminal common duct could be satisfactorily negotiated with a dilator, but did not distend with a saline flush. Thus, it was not possible to clarify the nature of the impediment to the flow of the contrast agent. Was it spasm,

edema or a calculus? Choledochoscopy revealed marked papillary edema (Fig. 3 *B*).

The duct was closed over the T-tube, and cholangiography on the eighth postoperative day confirmed the complete patency of the common bile duct with free entrance of opaque medium into the duodenum.

Comment. It is not uncommon to find that the opacifying medium does not enter the duodenum in spite of the failure to palpate abnormalities. This apparent obstruction cannot be altered by the force of injection or by the quantity of medium utilized. It has been repeatedly demonstrated that such temporary obstruction may be produced by ampullary or peri-

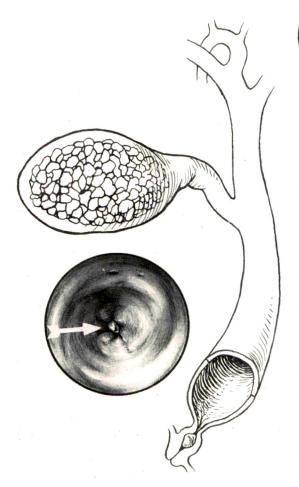


Fig. 5. Case III. The endoscopic appearance of a small, solitary facetted stone in the distal common duct (arrow).



Fig. 6. Case IV. Endoscopic appearance of an impacted ampullary calculus, accompanied by catarrhal cholangitis. The diagnosis of cholangitis can be made only by choledochoscopy.

ampullary edema. This problem can be resolved by choledochoscopy, eliminating the need for exploratory duodenotomy in the absence of organic obstruction.

Case II. Large Solitary Calculus in the Distal Common Duct with Cholangitis. A 73 year old woman was admitted because of 6 months of recurrent episodes of jaundice. A cholecystectomy had been performed 23 years before. An upper gastrointestinal series was considered normal. An intravenous cholangiogram showed no visualization of the biliary tract. It was decided to visualize the biliary tree by the percutaneous transhepatic route. This study showed dilatation of the common and hepatic ducts and their branches, as well as a cystic duct stump measuring about 4 cm. in length

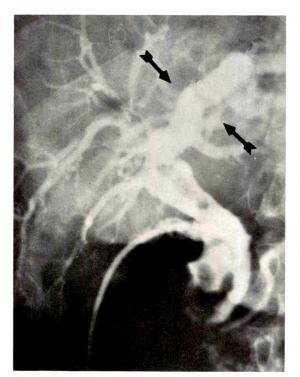


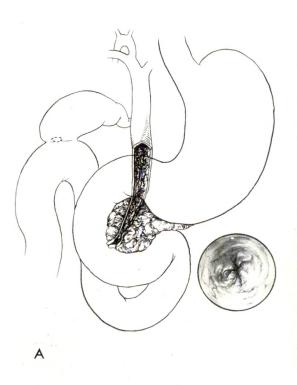
Fig. 7. Case v. The arrows point to a dilated left hepatic duct. Choledochoscopy disclosed a calculus impacted in the lumen of the left hepatic duct.

**→** ((((

(Fig. 4, A and B). A sharply circumscribed radiolucent stone with a convex superior border was seen in the distal end of the common duct. Initially, none of the opaque medium passed into the duodenum, and only a trickle was seen on the delayed roentgenograms.

Choledochoscopy was performed, confirming the presence of a large calculus in the distal common duct. In addition, cholangitis was noted throughout the common and major hepatic ducts.

Comment. Thus, in this instance the complementary modalities of transhepatic cholangiography and choledochoscopy



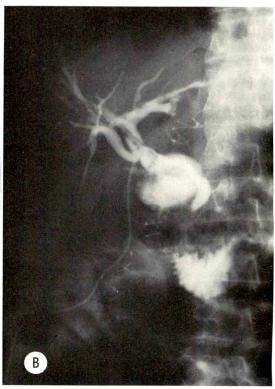


Fig. 8. Case vi. (A) The round insert shows the endoscopic appearance of a granulomatous cholangitis. The distal common duct is narrowed due to chronic pancreatitis with nodular enlargement of the head of the pancreas. (B) Postoperative T-tube cholangingram showing deviation of the distal common duct by the nodular pancreatitis, but offering no evidence of cholangitis.

demonstrated a common duct calculus; additionally, choledochoscopy disclosed the associated cholangitis which could not be otherwise diagnosed.

CASE III. Solitary Facetted Stone in the Common Bile Duct. A 58 year old woman was seen with acute right upper quadrant pain, vomiting, chills, and obstructive jaundice of 3 days' duration. The important laboratory data showed leukocytosis and a normal serum amylase. At operation, an acute obstructive cholecystitis was encountered. The gallbladder contained many facetted calculi. The cystic duct was dilated (12 mm.) and the common duct measured 1.8 to 2 cm. Choledochotomy showed a single facetted calculus impacted in the ampulla.

Comment. In this situation no provision had been made for operative cholangiography. Because facetted calculi are usually multiple, the finding and extraction of only one stone in the duct left the surgeon uncertain. Choledochoscopy, however, revealed the biliary tree to be free of other intraluminal calculi (Fig. 5). This finding was confirmed by a normal postoperative cholangiogram.

Case IV. Impacted Ampullary Calculus with Catarrhal Cholangitis. A 52 year old woman had complained of minor dyspepsia and right upper quadrant discomfort for several years. Oral cholecystography performed I year before showed nonopacification of the gallbladder. Her present admission was brought about by severe epigastric pain, chills, fever, jaundice, and leukocytosis. The serum amylase was normal. Physical examination elicited upper abdominal rigidity and rebound. The patient was operated upon with a preoperative diagnosis of acute calculus cholecystitis and common duct stone.

At operation the gallbladder was found to contain calculi and was acutely congested and edematous. The common duct was dilated due to a calculus impacted in the ampulla. Large hyperplastic lymph nodes surrounded the common duct, the lumen of which contained turbid bile with much mucus. Choledochoscopy showed dilated submucosal blood vessels characteristic of congestion, and findings diagnostic of catarrhal cholangitis (Fig. 6). Cholecystectomy, choledochotomy with T-tube drainage,

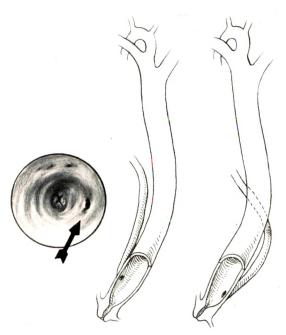


Fig. 9. Case VII. The endoscopic appearance of a long cystic duct stump. The arrow points to the orifice of the cystic duct which is in the right wall of the distal common duct, just above the ampulla.

and dilatation of the ampullary sphincter were performed. Histologic examination of a common duct biopsy confirmed the endoscopic impression of cholangitis.

Comment. Confirmation of the clinical diagnosis of cholangitis, suggested by a history of chills, fever and jaundice, can be made only by choledochoscopy. Cholangiograms cannot demonstrate this change. It is therapeutically and prognostically important to demonstrate the cause of cholangitis—in this instance, an impacted ampullary calculus.

Case v. Nonpalpable Stone in the Left Hepatic Duct. A 72 year old man had been operated upon for a presumed carcinoma of the head of the pancreas. A cholecystojejunostomy had been performed. Two years later re-exploration was undertaken for recurrent cholangitis and a chronic pancreatitis was found. An operative cholangiogram revealed marked dilatation of the left hepatic duct with no obvious calculi (Fig. 7). Choledochoscopy disclosed a stone impacted in the left hepatic duct.

Comment. Choledochoscopy revealed the cause for a localized hepatic duct ectasia, not defined by palpation, and not convincingly demonstrated on the operating room cholangiogram.

Case VI. Cholecystojejunostomy with Granulomatous Cholangitis. A 69 year old male was admitted  $2\frac{1}{2}$  years following cholecystojejunostomy at another hospital for what was believed to have been a carcinoma of the head of the pancreas. Following this initial procedure, the patient showed considerable improvement, but I year postoperatively, he presented with frequent bouts of recurrent chills, fever, and jaundice. In view of his good condition and the absence of demonstrable metastases, the patient was re-operated upon for cholangitis. At operation, the cholecystojejunostomy was dismantled, a cholecystectomy performed and the common duct was explored. Numerous stones were removed from the common duct and considerable debris and "mud" were flushed out. Chronic pancreatitis was present; the enlarged head of the pancreas deviated the distal common duct. Choledochoscopy showed a diffuse granulomatous cholangitis, with considerable narrowing of the duct in its distal portion (Fig. 8 A).

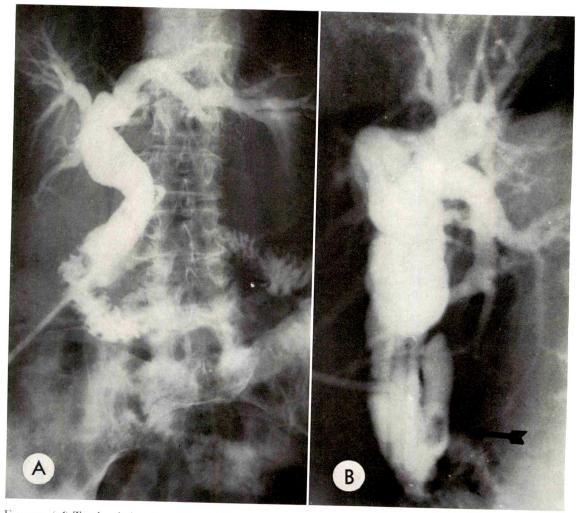


Fig. 10. (A) T-tube cholanging ram, frontal projection, showing dilatation of the common duct and hepatic ducts. (B) Lateral projection showing a cystic duct stump containing a radiolucent calculus (arrow). The cystic duct stump is directly posterior to the common duct and can be obscured unless a true lateral projection is obtained.

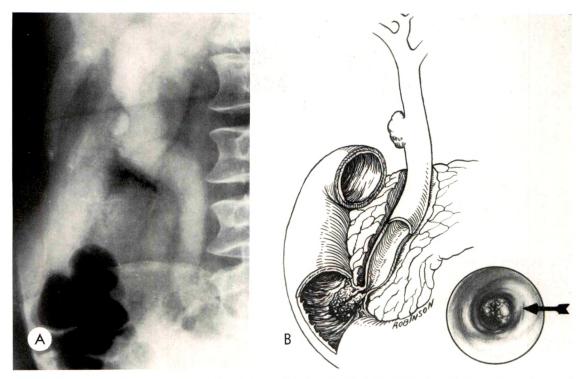


Fig. 11. Case VIII. (A) Intravenous cholangingram showing considerable dilatation of the common duct and its radicles. The cause for the dilatation is not apparent. (B) Choledochoscopy disclosed a polypoid neoplasm of the ampulla.

Comment. Endoscopic confirmation of the presence of cholangitis and of the terminal extrinsic narrowing indicated the need for permanent internal decompression by choledochoduodenostomy. Postoperative T-tube cholangiography (Fig. 8B) offered no indication of the extent of the cholangitis or of its severity. Contrast medium entered readily into the duodenum via the surgically created shunt. The deviation of the distal common duct by the nodular pancreatitis was documented.

Case VII. Anatomic Delineation of a Cystic Duct Stump. The role of choledochoscopy in the evaluation and management of a cystic duct stump syndrome was made clear in a patient whose biliary tree was examined endoscopically during a postmortem procedure. This examination was undertaken as part of one of our early anatomic studies to review the normal variations of the hepatic ducts. This patient had died of heart disease. The gallbladder had been removed many years before. The cystic duct stump appeared to be about 1 cm. long and of

the angular type. However, endoscopically the orifice of the cystic duct was visualized directly above the ampulla (Fig. 9). The duct was then dissected, and found to be of the long parallel type, attached to the right wall of the common duct.

Comment. On the basis of this experience, choledochoscopy may be regarded as an aid in defining the accurate site of entrance of the cystic duct. Such a situation has been dramatically documented on a movie strip showing the interior of the distal common bile duct during choledochoscopy. Cholangiographic studies in this respect have demonstrated that the routine anteroposterior and oblique roentgenograms do not always demonstrate the entire course of the cystic duct (Fig. 10A). For this purpose a true lateral cholangiogram is necessary (Fig. 10B).

Ordinarily, this view is not easily obtained in the operating room nor has it often been used in the routine intravenous



Fig. 12. This case shows two normal variations: the common duct is very narrow throughout, preventing insertion of a choledochoscope; and the common duct enters into the third portion of the duodenum, a variation encountered in about 8 per cent of cases. This knowledge is important to the surgeon, particularly if duodenotomy is contemplated.

cholangiographies. Direct endoscopic visualization at the operating table may aid in the proper management of a cystic duct stump.

Case VIII. Carcinoma of the Ampulla of Vater. A 65 year old female was admitted because of upper abdominal pain, with tenderness and rigidity in the right upper quadrant. A chole-cystectomy had been performed 15 years prior to admission. An intravenous cholangiogram showed a dilated common duct with obstruction at its terminal segment (Fig. 11 A). An upper gastrointestinal series demonstrated no abnormality in the duodenal loop. Choledochoscopy disclosed a polypoid tumor of the ampulla (Fig. 11 B); frozen sections showed this to be

adenocarcinoma. This patient has remained well for I year following a pancreatoduodenectomy. This is the earliest ampullary carcinoma that we have treated.

## $\begin{array}{c} \text{CRITIQUE OF CHOLANGIOGRAPHY} \\ \text{ADVANTAGES} \end{array}$

- 1. All of the surgically important segments of the biliary ductal system may be visualized.
- 2. The surgeon can be alerted to anatomic variations such as the insertion of the common duct into the third portion of the duodenum (Fig. 12), an occasional fishhook deformity of the distal end of the common duct (Fig. 13), a long cystic duct stump with insertion into the distal end of the common duct, or an accessory right hepatic duct.
  - 3. Multiple lesions may be demonstrated.

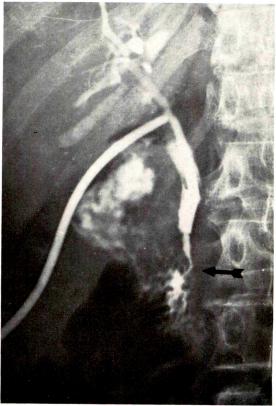


Fig. 13. A fish-hook deformity of the distal common duct (normal variant) may represent an obstacle to the rigid choledochoscope.

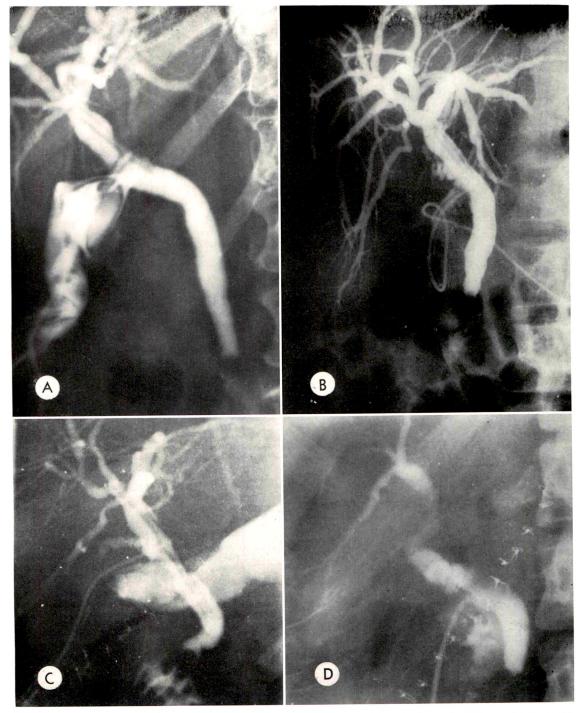


Fig. 14. Four examples of obstruction in the distal end of the common duct having a similar roentgenographic appearance, which choledochoscopy attempts to differentiate. ( $\mathcal{A}$ ) Polyp; ( $\mathcal{B}$ ) calculus; ( $\mathcal{C}$  and  $\mathcal{D}$ ) spasm.

- 4. A permanent record is available, permitting objective and subsequent comparative study.
- 5. The procedure is not technically difficult and is relatively safe.
- 6. The interpretation and final evaluation can be made by consultation between the surgeon and radiologist.

#### DISADVANTAGES

- 1. The apparatus required in the operating room may be cumbersome.
- 2. Explosive hazards necessitate the use of "explosion proof" roentgenographic equipment, influencing the choice of anesthetics.
- 3. The maintenance of an intact sterile field during cholangiography may represent an inconvenience.
- 4. Operating room cholangiography may be time consuming.
- 5. Sensitivity to opacifying media, although not a significant problem, may occasionally be encountered.
- 6. Radiation exposure to the surgeon and/or radiologist occurs.
- 7. Small, nonobstructing calculi or so-called "mud" may not be easily detected.
- 8. Repeat roentgenograms may be required to evaluate problems of spasm, air bubbles, or technical artefacts.
- 9. Pancreatitis has occasionally been precipitated by cholangiography.

## CRITIQUE OF CHOLEDOCHOSCOPY ADVANTAGES

- I. Visual differentiation of obstructing lesions in the distal common duct, which often cannot be made roentgenographically (calculus, polyp, carcinoma, spasm, papillary edema, etc.) is possible (Fig. 14, A, B, C and D).
- 2. The examination is under the direct control of the operating surgeon.
- 3. Choledochoscopic examination adds only a few minutes to the operative procedure.
  - 4. No auxiliary personnel is required.
  - 5. No contrast medium is needed.

- 6. The choledochoscope is readily available
- 7. Choledochoscopy is the only accurate method of diagnosing cholangitis *in vivo*.

#### DISADVANTAGES

- 1. The technique of endoscopy and the interpretation of the normal and abnormal anatomic findings are only acquired by experience.
  - 2. Choledochotomy is required.
- 3. Anatomic variations may make it impossible or imprudent to use the choledochoscope.
- 4. In long segment strictures the choledochoscope is generally of little value, since only the apex of the narrow segment can be visualized.
  - 5. The pancreatic duct cannot be seen.

#### SUMMARY

- 1. The modified Wildegans choledochoscope and its use in the operating room are described.
- 2. The methods of cholangiography are briefly listed.
- 3. A critical evaluation of cholangiography and choledochoscopy is presented, with emphasis on the limitations and advantages of each modality.
- 4. In 8 of 54 cases subjected to both procedures, the combined use of cholangiography and choledochoscopy has solved a problem which could not be resolved by either method used alone.

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# THE ROENTGEN RECOGNITION OF INTRAMURAL PERFORATION FOLLOWING BARIUM ENEMA EXAMINATION IN OBSTRUCTING LESIONS OF THE SIGMOID\*

By GENE W. SPECTOR, M.D., and NOAH SUSMAN, M.D. st. louis, missouri

THERE is an abundant literature dealing with the various roentgenographic findings following perforation of the rectum and sigmoid. These include emphysema of the lower extremity, retroperitoneal, mediastinal and cervical emphysema, as well as barium in the peritoneal cavity. A review of the literature fails to reveal a description of subserosal retroperitoneal perforation of the sigmoid colon or contained perforation of the rectum following barium enema study.

Recently 2 cases of unrecognized perforation by barium enema associated with an obstructing carcinoma of the sigmoid colon were observed. In 1 case an intramural perforation of the sigmoid was discovered at surgery; in the other, a contained perforation of the rectum and subsequent free retroperitoneal spreading was not proved until after surgery. A review of the roentgenograms in each case disclosed a finding which should have immediately suggested the presence of extraluminal barium even though the extravasated barium appeared contained.

#### REPORT OF CASES

Case I. L.H., a 71 year old white female, entered the Jewish Hospital on July 8, 1960 with the chief complaint of abdominal distention and progressive obstipation. The history revealed that there was no passage of feces for a period of I week and a gradually distending abdomen. Roentgen examination of the abdomen on admission showed inspissated feces in a markedly distended large bowel, terminating abruptly in the distal sigmoid colon. No rectal gas was demonstrated. An emergency decompression cecostomy was performed on the date of admission. On July 15, 1960 a barium enema

examination was performed (Fig. 1) which showed complete obstruction in the sigmoid region. The patient had no unusual subjective complaints during or following the barium enema study. Eighteen hours after the procedure, her temperature was noted to be 103°F. with lower quadrant tenderness and a suggestion of a mass in this region.

On July 20, 1960 an exploratory laparotomy was performed which showed a distal sigmoid carcinoma about 8 cm. in length obstructing the bowel in this region. It was noted that 12 cm. of the bowel distal to the tumor was gan-

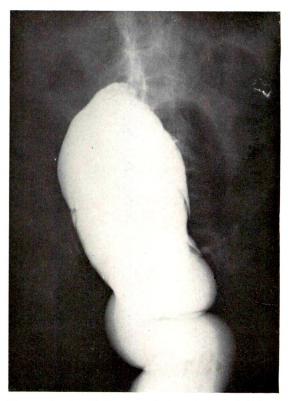


Fig. 1. Case I. Obstruction in sigmoid. Note oblique lines of diminished density in lateral walls of rectosigmoid.

<sup>\*</sup> From the Department of Radiology, The Jewish Hospital of St. Louis, St. Louis, Missouri,

grenous and necrotic. A primary resection which included the tumor and necrotic bowel was performed.

Pathologically it was found that the distal end of the resected specimen was grossly typical of adenocarcinoma. Distal to the carcinoma the segment of bowel measured 10 cm. Beginning 2 cm. from the distal edge of the carcinoma was a 5 cm. longitudinal clean-edge defect through the total thickness of bowel wall and continuous with a 4 cm. diameter cavity extending along the bowel subserosally with contained and adjacent pericolonic white friable thick cheesy material extending almost circumferentially about the bowel. The serosal reflection over the bowel containing the material was intact. Thrombosed vessels were seen in the areas of extravasated barium. The stage of organization of the thrombi in the vessels was equivalent to that of the reparative reaction to the extravasated barium, and it appeared that the escape of barium occurred at the same time as the vascular thrombosis. There was no anatomic evidence to suggest that the wall of the bowel was necrotic prior to the barium enema examination.

This finding was wholly unsuspected and a review of the original roentgenograms showed a membrane to be clearly visible within the gross barium column. This membrane represented the mucosa and muscularis propria. The barium lying peripheral to this membrane was extraluminal even though contained by the serosa. The dissection of the mucosa and muscularis propria from the serosa resulted in interruption

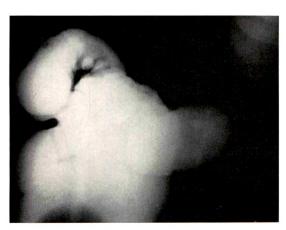


Fig. 2. Case II. Barium enema study showing the carcinoma and subserosal barium outlining left lateral wall of rectosigmoid. Note smooth contour of the extraluminal barium.

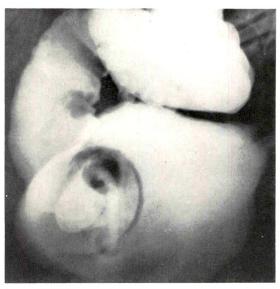


Fig. 3. Case II. Chassard-Lapine view of rectum showing abnormal distance from Bardex bag to left lateral wall of what was erroneously interpreted as a sigmoid loop. This is subserosal barium presenting the membrane sign of the lateral rectal wall.

of the vascular supply to the bowel with secondary gangrene.

CASE II. G.K., an 83 year old white female, entered the Jewish Hospital on January 10, 1961 with the chief complaint of abdominal swelling and severe constipation for a period of 5 days. An admission plain roentgenogram of the abdomen showed a distended large bowel as far distally as the sigmoid region. A barium enema study revealed a completely obstructing lesion in the sigmoid which was interpreted as carcinoma (Fig. 2 and Fig. 3). A decompression cecostomy was performed. The postoperative course was complicated by mental disorientation, electrolyte imbalance and episodes of hypotension. Fluid and electrolyte therapy improved her clinical condition. She underwent abdominal laparotomy on February 9, 1961. There was an intense inflammatory reaction accompanying the tumor which communicated with an abscess cavity in the mesentery. This was also resected. The patient did well following surgery but maintained a temperature of about 100°F. for several days.

On February 16, 1961 foul purulent drainage was noted from the rectum. Rectal examination showed an abscess 10 cm. from the anus draining anteriorly into the rectal lumen.

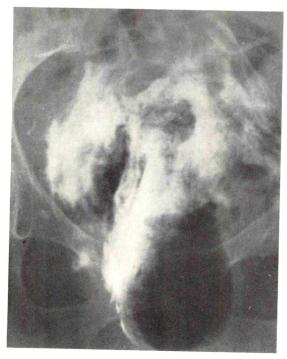


Fig. 4. Case II. Retroperitoneal barium partially surrounding rectal ampulla and sigmoid. Barium has escaped from serosal containment.

A review of the barium enema roentgenograms showed a portion of the rectosigmoid wall to appear as a membrane within the gross barium column. A retrospective diagnosis of an apparently localized extraperitoneal perforation at the time of the barium enema examination was made. This was then confirmed by a roentgenogram of the rectal region which showed the more usual appearance of barium freely extravasated in the extraperitoneal region (Fig 4). The patient did well and was discharged shortly thereafter.

#### EXPERIMENT

The membrane sign was reproduced experimentally as follows (Fig. 5): From an autopsy case one foot of normal sigmoid was removed. The lumen of this bowel was filled with barium under moderate pressure; both ends of the bowel were sealed. Barium was then injected subserosally through a small needle at one point along the antimesenteric side of the bowel.

#### DISCUSSION

The factors causing perforation in the 2 cases presented include the distended Bardex bag and an obstructing sigmoid lesion. The presence of the obstructing lesion in the sigmoid colon and the inflated Bardex bag in the rectum created a closed segment of bowel. Into this segment, barium was forced during the enema examination. The high intraluminal pressure contributed to the abnormal escape of barium. In I case, however, the escaping barium was limited by the serosa of the bowel. This outermost component of the intestinal wall is a loosely adherent envelope. A cleavage plane between this layer and the underlying muscularis propria is easily demonstrated at the autopsy table. When colon perforation occurs within the peritoneal cavity, the entire thickness of bowel wall is disrupted, including the serosal investment. However, as demonstrated here in Case 1, intraluminal perforation of the sigmoid may occur, allowing the extravasated material to burrow between the serosa and muscularis propria. When this event takes place during a barium enema examination, the muscular wall of the involved bowel may be outlined as a membrane between the intraluminal and extraluminal barium. It is presumed that the eventual escape of the barium contained by the serosa is probably due to necrosis of the serosa secondary to interrup-



Fig. 5. Membrane sign produced experimentally. See text.

tion of vascular supply. This, in turn, is caused by infection, thrombosis and mechanical destruction of vessels. Awareness of this unique roentgen appearance should alert the radiologist to the probability of occult perforation caused by barium enema in patients with severely obstructing lesions of the sigmoid.

It is apparent from the above 2 cases that barium which appears contained and does flow freely into the intraperitoneal space, or which dissects widely in the extraperitoneal space, is not necessarily intraluminal. The membranes clearly demonstrated a portion of the barium to be extraluminal even though giving the appearance of being contained. In the first case, the barium was kept contained by the intact serosa of the sigmoid; in the second case, it gave the momentary appearance of apparent containment in the perirectal soft tissue but was later shown to have the more usual appearance associated with extravasation of contrast medium in this region.

#### SUMMARY

A roentgen finding not previously described is presented which indicates contained retroperitoneal perforation caused by barium enema in patients with highly obstructing lesions of the sigmoid colon.

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## BARIUM GRANULOMA OF THE RECTUM\*

## A COMPLICATION OF DIAGNOSTIC BARIUM ENEMA EXAMINATIONS

By R. W. CARTER, M.D. BIRMINGHAM, ALABAMA

 $m B^{ARIUM}$  granulomas of the rectum result from the deposition of barium sulfate and fecal material beneath the mucosa, submucosa and deeper layers of the rectum. This occurs at the time of a diagnostic barium enema examination. There may be a predisposition to perforation from preexisting pathology (such as anal fissure, anal ulcer, infected crypts, diverticula or malignancy, etc.) or it may be produced entirely by trauma to the rectal mucosa from the catheter or its inflated bulb. This permits barium sulfate to pass outside the rectal lumen. The fecal particles which invariably accompany the barium in such a tear produce the acute process since sterile barium sulfate alone would cause very little reaction. The rectum can tolerate more intraluminal pressure than any other part of the gastrointestinal tract, and this no doubt contributes to the low incidence of barium granuloma.3

Eight cases of barium granuloma of the rectum have been reported. 1,4,5,6,7 The 2 cases of Burnikel² are not included since he did not consider them to present the same problem as found in the above references. Barium granuloma of the rectum has not been described in the radiologic literature. The present case, the ninth, is reported because it is considered important for radiologists to be aware of this complication and to guard against it.

Lesions less than I week old show mild inflammation and free barium crystals microscopically. Lesions of greater duration than I week show evidence of more chronic infection and multinucleated foreign body giant cells with intracytoplasmic and free barium sulfate crystals. This is followed by an abscess which may spon-

taneously drain at the site of the original entry or it may require drainage. Clinically, the lesions can not be differentiated from carcinoma and repeated biopsy may be necessary.

Injuries below the peritoneal reflection do not usually cause pain at the time they occur and they may not be diagnosed until local and/or systemic signs of infection develop.

#### REPORT OF A CASE

This patient, a 69 year old white female, entered the hospital with the complaint of diarrhea with passage of bloody mucus. A barium enema study was performed as part of the diagnostic workup. The patient experienced no unusual pain or other symptoms at the time of the examination, but later in the day she developed pain, cramping and rectal bleeding. For this, she was treated with local applications of an anesthetic ointment and hot sitz baths.

Proctoscopic examination a week later revealed indurated slightly nodular areas on the anterior rectal wall and on the right lateral and right posterolateral wall. There was hyperemia of the rectal mucosa and a visible ulcerative defect on the anterior wall extending 4 inches cephalad. The base of this area was dirty gray and necrotic in appearance. A biopsy was performed and microscopic examination revealed it to be made up of richly vascular granulation tissue containing a few entrapped mucosal glands. These glands were distorted and the relationship was lost. Contained in the granulation tissue were large histiocytes, plasma cells and scattered polymorphonuclear leukocytes. On examination with polarized light, very finely divided anisotropic material was demonstrated in some of the histiocytes and lying free in the granulation tissue. Foreign body giant cells were not demonstrated. The microscopic diagnosis was "barium granuloma from rectum."

<sup>\*</sup> From the Department of Radiology, Norwood Clinic and Carraway Methodist Hospital, Birmingham, Alabama.

A review of the barium enema roentgenograms revealed a few diverticula. The filled study showed no other unusual findings in the colon. The Bardex bulb was inflated to a fairly large size (Fig. 1). The postevacuation roentgenogram showed the barium adjacent to the rectum to have a rather striated appearance, representing the barium which had now passed into the tissue of the rectal wall and perirectally (Fig. 2).

Roentgenograms of this area taken almost 2 years later showed that the barium was still present with essentially the same appearance (Fig. 3).

The patient remained in the hospital for 3 weeks after the barium enema examination. Treatment consisted of low residue diet and antispasmotics. Chloromycetin and sulfasuxidine were used for bowel sterilization. She responded well to this treatment and at present has no symptoms relative to the previous granuloma.

#### DISCUSSION

The barium enema examination is one of the most frequently performed of all diagnostic procedures used by the radiologist. It is usually carried out with ease, particu-

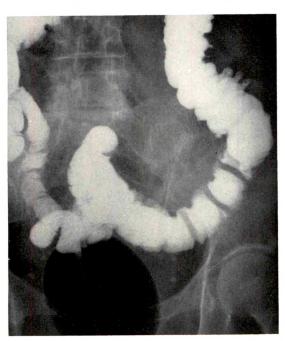


Fig. 1. Filled barium enema roentgenogram. Some diverticula are present in the sigmoid colon. The Bardex bulb is fairly large.



Fig. 2. Postevacuation roentgenogram. The barium near rectum has striated appearance. It has now passed submucosally and into the deeper perirectal tissues.



Fig. 3. Almost 2 years later the barium remains and shows very little change. The patient presented no symptoms relative to the previous granuloma.

larly in any patient not of advanced age.

It is in patients of more advanced age that technical difficulty in filling the colon is most frequently encountered. Since the incidence of significant pathology is also greater in this group, the radiologist is often faced with the problem of not completely filling the colon and running the risk of a missed diagnosis or of making too vigorous an effort for complete filling and perhaps encountering such complications as are described here.

Inflating the balloon cathether to a rather large size is frequently the determining factor in whether or not an adequate examination can be done in the elderly or debilitated patient. In many of these patients it would be impossible to obtain complete filling of the colon without such an aid.

Considering the frequency with which this procedure is performed and the apparent low incidence of barium granuloma and its relative benignancy, it is thought that the radiologist should not be deterred by the small risk from inflating the bulb to a necessary size when he is called upon to exclude major colon pathology which could not otherwise be diagnosed short of laparotomy.

#### SUMMARY

1. The ninth case of barium granuloma of the rectum is reported. This is the first case to be described in the radiologic literature.

- 2. It appears likely that many radiologists, therefore, would not be familiar with this condition.
- 3. It is a complication of the diagnostic barium enema examination and should be guarded against.
- 4. In patients where an adequate study of the colon cannot be done without the aid of an inflated Bardex bulb, it is thought that the risk of barium granuloma is well worth taking, since the benefit of an adequate colon study far outweighs the risk of this complication.

Norwood Clinic 1529 North 25th Street Birmingham, Alabama

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### AN EXPERIMENTAL STUDY OF THE EFFECTS OF BARIUM AND INTESTINAL CONTENTS ON THE PERITONEAL CAVITY\*

By DONALD Q. COCHRAN, M.D.,† CARL H. ALMOND, M.D.,‡ and WILLIAM A. SHUCART, M.D.

COLUMBIA, MISSOURI

 $B_{
m as\ the\ contrast\ medium\ of\ choice\ in\ the}^{
m ARIUM\ sulfate\ is\ universally\ accepted}$ roentgenographic examination of the gastrointestinal tract because of certain characteristics; namely, high roentgenographic density, low gastrointestinal absorption, and low cost. The rarity of reported complications attending its widespread use attests to its safety in competent hands. However, the possibility of complications occurring during its use, especially those involving spillage into the peritoneal cavity, prompted us to attempt to determine their nature and severity. We were particularly interested in comparing the effects of USP barium sulfate with those of a commercial barium preparation,\* and also in comparing the effects of barium sulfate alone with those of barium plus intestinal contents.

A survey of recent American literature revealed only scattered reports of accidental spillage into the peritoneal cavity, mostly in the nature of isolated case reports.<sup>2,3,4,7,8,10,12,13</sup> A few animal experiments which simulated clinical conditions have been carried out, and these tend to indicate that bacterial contamination by intestinal contents is the most significant factor in determining morbidity and mortality.<sup>5,6,11,12,14,15</sup> From these few reports, it has been impossible for us to formulate a clear impression as to the immediate and long term hazards associated with peritoneal contamination by barium sulfate.

#### OBJECTIVES

It is the purpose of this study to compare the effects on the peritoneal cavities of dogs of a commercial barium sulfate preparation, USP barium sulfate, and sterile and unsterile feces, alone and in various combinations.

In a previous report, we compared the effects of a commercial barium sulfate preparation\* and two water soluble media.¹ From this study, it was concluded that barium sulfate has a deleterious effect on the peritoneal cavity which is not observed with water soluble media. Other investigations, however, suggested that perhaps the effects attributed to the barium sulfate were, in fact, due to other components of the commercial barium preparation.¹ The present study is an attempt to clarify this problem.

#### PROCEDURE

Twenty-nine healthy mongrel dogs, weighing from 10 to 18 kg. were used as test subjects. These were separated into several groups depending upon the type and combinations of material injected. All of the contrast media and all of the feces were injected into the peritoneal cavities percutaneously by a needle and syringe or through a small celiotomy incision made under sterile conditions. All animals had abdominal roentgenograms within 30 minutes after injection (Fig. 1) and a follow-up roentgenogram 2 to 5 days later (Fig. 2). A third roentgenogram was made 2 or 3

<sup>\*</sup> Stabarium-Keleket Corporation.

<sup>\*</sup> From the Departments of Radiology and Surgery, University of Missouri School of Medicine, Columbia, Missouri.

Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 2-5, 1962.

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<sup>†</sup> Assistant Professor of Radiology.

<sup>‡</sup> Assistant Professor of Surgery.

TABLE I

Group	No. of Animals	Material Injected	No. of Survivors	Celiotomy Findings in Survivors	Autopsy Findings
Ι	10	30 cc. nonsterile commercial barium	3	Granulomas and multiple adhesions in all	Diffuse hemorrhagic and purulent peritonitis with adhesions in some
II	5	30 cc. sterile com- mercial barium	3	Granulomas and multiple adhesions in all	Diffuse hemorrhagic peritonitis
III	3	15 cc. nonsterile commercial barium, 15 cc. nonsterile feces	0		Severe hemorrhagic peritonitis in all
IV	3	15 cc. nonsterile feces	I	No abnormalities	Diffuse peritonitis with multiple adhesions
V	3	15 cc. sterile feces	3	No abnormalities	
VI	5	30 cc. sterile USP barium	5	Granulomas in all, no adhesions	



months later on all survivors (Fig. 3). All animals that died were autopsied, and those that survived at least 3 months were explored to determine the condition of the peritoneal cavities. Postmortem or operative pathologic specimens were taken and photographs of the peritoneal cavities were made in some instances. The data are summarized in Table I.

Group I consisted of 10 animals. Thirty cubic centimeters of a 30 per cent aqueous suspension of a commercial barium sulfate preparation were injected into the peritoneal cavity of each with a syringe and needle. No special precautions were taken to sterilize the material prior to injection. Abdominal roentgenograms showed almost immediate dispersal of the contrast medium in the peritoneal cavities. Repeat roentgenograms made 2 to 5 days after injection showed widespread clumping of the bar-

× 1111

Fig. 1. Abdominal roentgenogram 30 minutes after intraperitoneal injection of 30 cc. commercial barium sulfate.

ium, probably due to absorption of water by the peritoneal surface and localization by fibrinous exudates. This pattern persisted unchanged in those animals which survived. All of the animals in this group appeared quite ill within hours after injection and 7 of the 10 were dead within 2 weeks. Autopsies showed severe hemorrhagic or purulent peritonitis in all, with extensive adhesions in those that lived more than a few days. The 3 survivors were subjected to exploratory celiotomy about 4 months after injection, and all showed extensive adhesions and barium granulomas with complete obliteration of the peritoneal cavity in one animal.

Group II consisted of 5 animals. The procedure used was identical with that used in Group I except that the barium

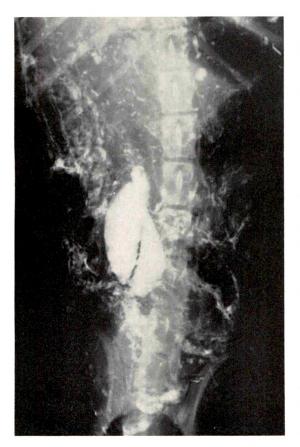


Fig. 2. Roentgenogram of same animal 5 days after injection.



Fig. 3. Roentgenogram of same animal 3½ months after injection.

suspension was sterilized by boiling for 30 minutes prior to injection, and sterile precautions were used in injecting it. Roentgenograms made immediately after injection and 2 to 5 days later showed the same findings as in Group I. Of this group, 2 died within 3 days after injection. Autopsies showed diffuse hemorrhagic peritonitis in both. The 3 survivors were explored about 3 months after injection, and numerous adhesions and barium granulomas were found.

Group III consisted of 3 animals. Fifteen cubic centimeters of unsterile commercial barium suspension and 15 cc. of unsterile feces were placed into the peritoneal cavity through a small celiotomy incision made under sterile conditions. Postoperative abdominal roentgenograms showed dispersal of the barium sulfate throughout the peri-

toneal cavity. Upon reacting from anesthesia, it was apparent that all 3 dogs in this group were quite ill, and all were dead within 24 hours. Autopsies showed diffuse widespread hemorrhagic peritonitis in all animals.

Group IV consisted of 3 animals. Fifteen cubic centimeters of an aqueous suspension of unsterile feces were injected into the peritoneal cavity of each animal. Two died within 10 days following injection, and both were found to have diffuse peritonitis and multiple adhesions. The third animal survived and at exploratory celiotomy  $2\frac{1}{2}$  months later, the peritoneal cavity was found to be entirely normal.

Group v also consisted of 3 animals. The procedure used was identical to that used in Group IV except that the fecal suspension was sterilized by boiling 20 minutes prior to injection. All 3 of these animals survived with no significant morbidity, and celiotomies  $2\frac{1}{2}$  months after injection showed no abnormalities of the peritoneal cavities.

Group VI consisted of 5 animals. Each had 30 cc. of a 30 per cent aqueous suspension of sterile USP barium sulfate injected into the peritoneal cavity. Abdominal roent-genograms made immediately after injection showed dispersal of the contrast medium throughout the peritoneal cavity, and follow-up roentgenograms 2 months later revealed clumping of the barium similar to that of Groups I and II. All 5 animals in this group survived, and celiotomies 2 months after injection showed numerous barium granulomas but there was no evidence of adhesions in any of these animals.

#### RESULTS

This study indicates that barium sulfate per se has an adverse effect upon the peritoneal cavity as evidenced by the formation of granulomas in all animals who lived long enough for this phenomenon to occur (Groups I, II and VI). However, the commercial barium preparation was shown to have a more adverse effect than USP barium by the high mortality rate and by the uniform formation of dense adhesions

(Groups I and II) which were not seen with USP barium (Group VI).

The deleterious effects of fecal material in the peritoneal cavity were shown to be due to the accompanying infection (Group IV). In the one animal that recovered following the injection of unsterile feces and in those which were injected with sterile feces (Group V), no permanent damage was observed.

The combination of commercial barium and unsterile feces was shown to be more deleterious than either alone, confirming the well known fact that infection is aggravated by the presence of foreign material.

#### DISCUSSION

Although barium sulfate has been shown to be injurious to the peritoneal cavity, it is evident that certain other materials in the commercial barium preparation used produced a more adverse effect than the barium per se. The preparation studied contains an "inert agent" presumably added for the purpose of keeping the material in suspension. This agent does not appear to be entirely inert when placed in the peritoneal cavity.

In a clinical situation involving peritoneal contamination by barium and alimentary tract contents, infection would seem to be more important than the foreign material itself in determining the severity of the immediate complications. However, the propensity for the commercial barium sulfate preparation to produce adhesions would lead one to expect an increase in the likelihood of long term complications.

#### SUMMARY

- 1. A comparative study of the effects on the peritoneal cavity of the dog of 2 different barium sulfate preparations and of sterile and unsterile feces, alone and in various combinations, was carried out.
- 2. Barium sulfate was shown to have a deleterious effect on the peritoneal cavity, but comparison of the effects of commercial and USP barium shows that the suspending agent in the commercial preparation is ap-

parently more harmful than the barium itself.

- 3. The combination of barium and unsterile feces was shown to be much more deleterious than either alone.
- 4. The hazards of fecal spillage into the peritoneal cavity are fundamentally due to infection rather than to foreign material.

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Forty-fifth Annual Meeting: Mark Hopkins Hotel, San Francisco, Calif., April 1-4, 1963.

#### ≈ E D I T O R I A L S ≈

#### ALL SPEED AND NO CONTROL

"ALL SPEED" refers to the speed with which a colon contracts following a barium enema containing tannic acid. "No control" refers to the fact that pharmacologically, tannic acid has a very poorly controlled scientific basis for its use; particularly the written facts concerning its absorption from the colon and its toxicity.

The dictum, "we've been doing that for years and nothing untoward has happened" is the empiric approach and occasionally it is the only evidence available on toxicity or the side effects of a drug. However, as science has replaced "clinical impression," a more critical approach to even the simplest maneuvery or drug has brought to light subclinical side effects found only by accurate, controlled laboratory or pooled (large number) statistical data.

Subclinical side effects, though recognized as present, may not contraindicate the carrying out of a procedure or use of a drug; the hazard may be worth the benefit. However, the knowledge of a hazard should produce an awareness which would make it possible and more likely to recognize toxicities of a lower order of magnitude. If they become of clinical importance, they will be recognized early and attributed to the proper cause; this then can be followed by early, properly directed treatment or removal of the toxic agent. The prime consideration is homeostasis of the patient.

While the simple and accepted often gets the least attention, the barium enema has had much written about it, but little directed, objective measurement has been taken on the pharmacodynamics of bowel distention by the enema from the point of view of the systemic or homeostatic mechanisms and the degree of significant mor-

bidity (or even mortality) that could ensue. Do chemical additives to the enema enhance a possible vago-vascular reaction capable of upsetting homeostasis? Are additives absorbed from the colon in a significant amount to produce or enhance the subclinical side effects of the enema alone? Should caution be exerted in the use of hazardous astringents that are added to the barium enema fluid?

Tannic acid (gallotannic acid) is often added to the enema fluid in 2.5 gram amounts. Its action on the bowel is direct, producing an astringent effect on the mucosa; a "coagulation" or "tanning" of the mucosal surface. This effect is used to stimulate the muscular mucosa to contract. Is there ever significant absorption of tannic acid which could produce acute toxicity? Does the vigorous contraction of the bowel produce enough untoward effects to be considered a challenge to the homeostatic mechanisms? Could two untoward effects (enema plus tannic acid toxicity) combine to initiate a chain of events yielding a decompensation of homeostasis?

Hearsay evidence says ves.

The literature contains little documentation of these variables under even a semblance of controlled experimentation. There is adequate documentation of the toxicity of tannic acid when absorbed "even in small amounts" (but how small is not stated) producing diffuse localized necrosis of the liver around the central vein. This fact was gathered following the use of tannic acid on skin burns, when large amounts of the drug were used. The chance of massive absorption was not only a possibility, but when it occurred, the patients showed toxicity immediately with a progressive downhill course, usually dying in 72–96

hours. This coincides with the data on rats injected with tannic acid parenterally. It is not known how much, if any, of the material from the experience with burn cases treated with tannic acid is applicable in the situation under discussion. Absorption of tannic acid or its products takes place from the bowel;\* especially, if elevated or reduced pH exists, as even tannic acid conjugates are dissolved with elevation or reduction in pH. This situation is probably rare in the lower intestine where pH usually remains in the physiologic range. The fact is, we really do not know how often or how much is absorbed from the colon. Many radiologists use tannic acid but no controlled studies of the incidence of side effects or morbidity (or even mortality) are

Use of a substance in humans may challenge many parameters—so many that we often consider human experiments as being without controls or at best poorly controlled. At the present time, acceptance for use of a drug that has had as little controlled animal experimentation as tannic acid, probably would not be allowed.\*\* Documentation of its absorbability and at least

some idea of the incidence of side effects would have to be detailed to the Food and Drug Administration before it could be considered. The total problem is a large one in that approximately 600,000† barium enema examinations employing tannic acid are estimated. Benefits have been advocated by some. The amount of hazard cannot be assayed as the incidence of toxicity is not known. How many other drugs that we as radiologists use are in this category? Would retroactive studies be of value in trying to find out about the incidence of use of tannic acid and its side effects? Or would it be necessary to carry out a prospective survey? Should a report be sent to a central, interested office or person on every dose of the drug of interest that is used? What other drugs used in Radiology carry a significant risk?

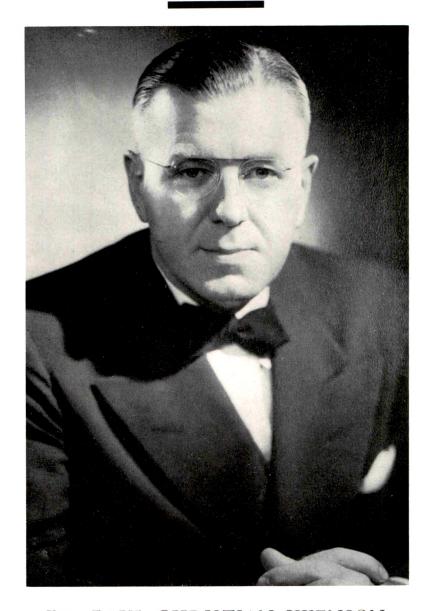
SYDNEY F. THOMAS, M.D.

34∞ Spruce Street Philadelphia 4, Pennsylvania

† Of the total number (85,000,000) of radiologic procedures performed per year, 3 per cent or 2,550,000 represent barium enema examinations. If one estimates that 25 per cent of the radiologists use tannic acid, then approximately 600,000 barium enemas with tannic acid are given annually. (Health Statistics Series B No. 38. "Volume of X-Ray Visits" U. S., 1960-61, USPHS.)



<sup>\*</sup> Recent data by Margulis et al. are to be published.
\*\* HALWORTH, R. D. Chemistry of tannin. Brit. J. Adv. Sc.,
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DR. PAUL CHRISTIAN SWENSON 1901–1962

PAUL CHRISTIAN SWENSON died in Columbia, South Carolina, on December 15, 1962. His sudden death, which occurred while he was visiting at the home of a colleague, was attributed to coronary thrombosis. He had been actively engaged in practice until the last, being chief radiologist at the Veterans Administration

Hospital in Columbia at the time of his death.

Dr. Swenson was born in Duluth, Minnesota on May 3, 1901, the son of the late Christian and Caroline Stephenson Swenson. His father was a minister in the Lutheran Church whose calling occasioned many family relocations during Dr. Swenson

son's early life. He obtained the usual preliminary education in several Minnesota towns and cities. He then entered the University of Minnesota and was graduated in 1925. After his internship at Ancker Hospital in St. Paul, he received the degree of Doctor of Medicine in 1926.

He engaged in general practice for a year and then became a resident in radiology at the University of Michigan under the late Preston Hickey. He remained at Ann Arbor for two and one-half years after which he went to Columbia University Medical Center in New York where he continued his career in radiology. He stayed at Columbia from 1930 to 1943, except for some study at the Cancer Institute in Stockholm in 1937. While at Columbia he rose from the rank of instructor of medicine to assistant professor of radiology.

Dr. Swenson accepted the position of Professor of Radiology at Jefferson Medical College in Philadelphia in 1943. He remained at Jefferson until 1955. After leaving there, he was in the private practice of radiology in Philadelphia and in St. Paul

until 1960, when he became associated with the Veterans Administration Hospital in Columbia.

During Dr. Swenson's academic life he contributed many articles to the current radiologic literature and also to textbooks published during that time. He was deeply interested in various organizations, particularly medical groups. He also was diligent in maintaining his affiliation with his church. Among the medical groups with which he was associated were the American Roentgen Ray Society; the Radiological Society of North America; the Philadelphia Roentgen Ray Society; the American Association for the Advancement of Science; the American Trudeau Society; the American Radium Society; the American Cancer Society and the American College of Radiology in which he was a Fellow.

Surviving are his widow, Mrs. Ruth Kathryn Johnson Swenson; and two sons, Dr. John A. Swenson of Miami, Florida and Paul Richard Swenson of New York City.

J. P. MEDELMAN, M.D.



#### **NEWS ITEMS**

#### FIFTIETH ANNIVERSARY OF THE CHICAGO ROENTGEN SOCIETY

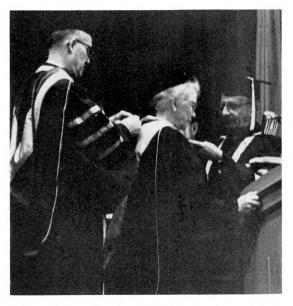
On February 7, 1963, the Chicago Roentgen Society celebrated its Fiftieth Anniversary at the Pick-Congress Hotel, Chicago, Illinois, by a festive Commemorative Program, as part of the program of the Thirty-ninth Annual Meeting of the American College of Radiology. The distinguished speakers of the evening were Dr. Howard P. Doub, Detroit, Michigan, Editor of Radiology; Dr. Leo G. Rigler, Los Angeles, California; Dr. Benjamin H. Orndoff, Park Ridge, Illinois; and Dr. Earl E. Barth, Chicago, Illinois, President of the American Roentgen Ray Society.

Dr. Orndoff, whose illustrious career represents one of the most documentative facets of American Radiology, in his inspiring reminiscences titled "Memories' stated: "When the call went out to form a national Society of Roentgenology, composed only of medical graduates who devoted a large share of their work to X-Rays, there arose a strong feeling of competition and strife which exploded so to speak, when the first national Roentgen Society was formed in the year 1900, in St. Louis, Missouri. After a few annual meetings of the national organization, the ideals of its membership became unified and organizations of Roentgenology and Radiology became stabilized and have served a most useful purpose in advancing science."

In Chicagoland of 1963, the Commemorative Program of the Golden Anniversary of the founding of its Roentgen Society epitomized this "most useful purpose in advancing science" with nostalgic overtones of the past and the forecast of a great future.

#### AMERICAN COLLEGE OF RADIOLOGY

At the Thirty-ninth Annual Meeting of the American College of Radiology held at the Drake Hotel, Chicago, Illinois, Feb-



The Gold Medal, the highest award of The American College of Radiology, is presented to Dr. Edith H. Quimby by Dr. Present (right) assisted by Dr. Wachowski (left).

ruary 6–9, 1963, the following officers were elected: *President*, Dr. Theodore J. Wachowski, Wheaton, Illinois; *Vice-President*, Dr. Harold O. Peterson, Minneapolis, Minnesota; *Secretary-Treasurer*, Dr. Fay H. Squire, Chicago, Illinois (re-elected); *Chairman*, *Board of Chancellors*, Dr. David S. Carroll, Memphis, Tennessee. Dr. Harold G. Jacobson, New York City, and Dr. Jarrell E. Miller, Dallas, Texas, were elected to the Board of Chancellors.

The Convocation Ceremonies were held on February 8, 1963. At these ceremonies Dr. Arthur J. Present, Tucson, Arizona, President of the College, conferred the degree of Fellow on 59 candidates, the degree of Associate Fellow on 1 candidate and the degree of Honorary Fellow on: José Landron Becerra, Cayey, Puerto Rico; Johann Frimann-Dahl, Oslo, Norway; Knut John Gustav Lindblom, Stockholm, Sweden; and E. Dale Trout, Corvallis, Oregon.

At the same ceremonies Dr. Present, as-

sisted by the new President, Dr. Wachowski, presented to Dr. Edith H. Quimby, New York City, the Gold Medal, the highest award of the American College of Radiology "for distinguished and extraordinary service to the College and to the profession for which it stands." A similar honor was extended *in absentia* to Dr. Antoine Lacassagne, Paris, France.

The Fortieth Annual Meeting of the College will be held at the Ramada Inn, Tucson, Arizona, February 5-8, 1964.

#### SECOND SYMPOSIUM OF RADIOCINEMATOGRAPHY

The Second Symposium of Radiocinematography will be held in Munich, Germany, on May 24 and 25, 1963. The program will feature radiocinematography in angiocardiography and coronary angiography, the use of radiocinematography by the general radiologist and the importance of film size. In addition to a refresher course in radiocinematography, there will be a panel discussion on improvement of radiodiagnosis by radiocinematography.

Inquiries and enrollment should be forwarded to Prof. Dr. K. Decker, Röntgenabteilung der Nervenklinik der Universität München, Nussbaumstr. 7, 8, München 15, Germany.

## SEVENTEENTH ANNUAL MEETING OF THE PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

The Pacific Northwest Radiological Society will hold its Seventeenth Annual Meeting on May 10, 11 and 12, 1963, at The Bayshore Inn, Vancouver, B. C., Canada.

Guest speakers will be Dr. Albert Jutras,

Montreal, and Dr. Richard H. Marshak, New York City. Papers of topics other than gastrointestinal will be presented at the Scientific Sessions and there will be a film reading session of interesting films, especially gastrointestinal.

For further information, please write to Dr. G. I. Norton, Program Chairman, 925 West Georgia, Vancouver 1, B. C., Canada.

### AMERICAN COLLEGE OF RADIOLOGY

An Ad Hoc Committee met in Chicago, February 9, 1963, with representatives of the National Council for Radiologic Heritage, to plan the publication of the history of Radiology in the United States and Canada. An appeal is made to gather written and pictorial material to be made available to the authors entrusted with compiling this history. The material should be sent before May 1, 1963 to Dr. Edwin C. Ernst, St. Louis, Mo., through the District Councilors or in care of Mr. Otha Linton of the American College of Radiology.

The District Councilors are: I. L. E. Haas, Boston, New England States; II. Philip J. Hodes, Philadelphia, North Atlantic States; III. F. O. Coe, Washington, South Atlantic States; IV. Howard Doub, Detroit, Eastern Central States; V. Benjamin Orndorf, Park Ridge, Ill., Western Central States; VI. H. Milton Berg, Bismarck, North Plains States; VII. Edwin C. Ernst, St. Louis, South Plains States; VIII. Vincent P. Collins, Houston, Gulf States; IX. Drs. Bouslog and Allen, Denver, Rocky Mountain States; and X. Robert Newell, San Francisco, Pacific States.

The Canadian radiologists are asked to send their material directly to Dr. Ernst, St. Louis.



## ABSTRACTS OF RADIOLOGICAL LITERATURE

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#### ROENTGEN DIAGNOSIS

#### GENITOURINARY SYSTEM

SMITH, ROBERT D. The obstructed bladder outlet in childhood. *Brit. J. Urol.*, Sept., 1962, 34, 304–311. (From: Royal Alexandra Hospital for Children, Sydney, Australia.)

Bladder-neck obstruction is by no means a rare condition, and it may be considered to be caused by actual narrowing or failure of the bladder neck or posterior urethra to relax adequately. The bladder is consequently prevented in varying degrees from emptying freely.

The pathology is uncertain, and it is believed by some to be a "fibro-elastosis" which leads to increased resistance to muscular stretching and causes urinary obstruction and back-pressure effects on the bladder and the upper urinary tract. It is stressed that these microscopic findings have been noted only in severely obstructed young males and have not definitely been demonstrated in mildly obstructed males or in females.

The symptomatology of bladder-neck obstruction is usually more severe in infancy, being manifested by renal failure of varying degree, or perhaps by distended bladder and overflow incontinence. In some cases the grossly dilated ureters and kidneys may be palpable. In the presence of urinary infection the diagnosis of bladder-neck obstruction should always be considered and a full history and clinical examination should be routine. The nature of the urinary stream and the amount of residual urine in the bladder should be carefully checked.

The treatment is surgical. The plastic procedures are of two types, first the Heineke-Mikulicz procedure where a longitudinal incision through the inferior aspect of bladder, bladder-neck, and proximal urethra is closed transversely. The second procedure is an inverted Y-shaped incision over the bladder-neck and closed as a V. In both these methods the normal bladder musculature is pulled into the fibrous ring which is effectively broken, thereby preventing recurrence of the obstruction.

The author gives his results in 5 boys and 16 girls. The overall impression is that the results were satisfactory in most of the cases.

The conclusion is reached that the treatment of the bladder-neck obstruction with bladder-neck plasty has been satisfactory in the cases operated on during the last 3 years.—Peter C. Truog, M.D.

#### NERVOUS SYSTEM

LOMBARDI, G., PASSERINI, A., and MIGLIA-VACCA, F. Spinal arachnoiditis. *Brit. J. Radiol.*, May, 1962, 35, 314-320. (From: Radiological and Surgical Departments, Neurological Institute, Via Celoria 11, Milan, Italy.)

The authors report on 41 patients with spinal arachnoiditis. All had myelographic studies and 31 had surgery. These 41 patients were so-called cases of pure arachnoiditis (free from interference by other lesions at the site, disturbing the clinical and roent-genologic findings). Secondary forms due to operation, fractures, and to infective spondylitis have been excluded along with those associated with angiomas, spinal tumors, disk herniation, diseases of the peridural space and reactions around residues of oily contrast medium.

The etiologic factors could be determined in 18 patients. The illnesses found in the histories of the other patients were either too common or too far back in time to be considered as the cause. In the 18 patients the etiologic factors were: 8 had a history of meningitis, 3 were preceded by trauma, 3 had a previous subarachnoid hemorrhage, 3 had histories of intrathecal injections of antitetanus serum and 1 had tuberculous meningitis.

A correct diagnosis was made after myelography in 58 per cent of the patients. A complete block of the cerebrospinal fluid was present in 27 of the 41 myelograms. Roentgenologic diagnosis was based on a polymorphous and bizarre-like distribution of adhesions. The contrast medium may be broken up in fragments blocked in enclosures which may be separate or communicating, described as "stalactite, stalagmite and multiple pocket images." At times, the contrast medium advances with difficulty along a narrow, winding canal which may end in a cul-desac or flow into the still normal subarachnoid space. Arachnoiditis of the most dependent parts obliterates and concentrically restricts the dural sac.

Arachnoiditis occurred in the thoracic region in 28 patients (68 per cent), the lumbar region in 7 patients, and the cervical area in 6.

With the single exception of the rare cystic forms which behave like tumors, arachnoidal adhesions do not displace the cord but are arranged peripherally like the bark of a tree. Spaced-out control examinations are important as time favors the penetration of the contrast medium into the recesses and indentations of the line of arrest. Since the adhesions may be circumscribed or diffuse it is helpful to introduce contrast material above and below the obstacle and determine the extent of the disease.

A condition which may simulate arachnoiditis is "multiple arachnoidal diverticulosis." This refers to pockets (usually small) which form among the meshes of the arachnoid, particularly on the posterior face of the dorsal spinal cord. When the contrast material descends from the cervical region with the patient erect, the diverticula are seen as small pockets with fluid levels.—Frank J. Rigos, M.D.

Lang, Erich K. Roentgenographic diagnosis of the neurovascular compression syndromes. Radiology, July, 1962, 79, 58–63. (From: The Department of Radiology, Johns Hopkins Medical School and Hospital, Baltimore, Md., and the Methodist Hospital, Indianapolis, Ind.)

Pain and numbness in an upper extremity frequently lack satisfactory explanation. Several well defined entities, according to causative mechanism, are known to exist and include (1) cervical rib syndrome, (2) scalenus anticus syndrome, (3) costoclavicular syndrome, (4) hyperabduction syndrome, and (5) the combined shoulder syndromes. Symptoms may be aggravated by coexisting dynamic, congenital, traumatic, hypertrophic and arteriosclerotic factors. The common denominator is pressure on some segment of the subclavian artery or vein, or the brachial plexus. The most common sites of pressure are the intervertebral foramina, the interscalene triangle, the cervical axillary canal, the costoclavicular space, and the region of encirclement of the axillary artery by the two heads of the median nerve.

The symptoms produced at these sites of pressure are neither consistent nor diagnostic of the underlying cause. Various maneuvers have been developed to help differentiate the various causes, but these are not always diagnostic, and combinations of causes may occur to further cloud the picture.

Roentgenographic examinations may reveal cervical ribs, and venous obstruction is easily demonstrated. Apparently the artery is more commonly compressed than the vein, and the author used arteriography by the Seldinger technique to demonstrate arterial compressions preoperatively. The catheter was advanced under fluoroscopic control and engaged in the ostium of the right or left subclavian artery. Several injections of 10 cc. of 50 per cent sodium diatrizoate were made in various positions and maneuvers, and the results were recorded on serial films exposed at the rate of 2 per second.

The author presents 4 case reports of patients with compression syndromes who were correctly diagnosed preoperatively with this technique, and who made good recoveries postoperatively. Correlation of arteriographic and surgical findings is said to be good, and it is felt that this examination is an essential preoperative test for proper diagnosis of neurovascular compression syndromes.—7. C. Moore, M.D.

Schultz, E. H., Jr., and Brogdon, B. C. The problem of subdural placement in myelography. *Radiology*, July, 1962, 79, 91–96. (Address: Dr. E. H. Schultz, Jr., Department of Radiology, University of North Carolina School of Medicine, Chapel Hill, N. C.)

Subdural placement of contrast medium almost always compromises the diagnostic accuracy of myelography and jeopardizes the success of future examination of the subarachnoid space. The purpose of this paper is to consider the cause, appearance, effect, and possible prevention of this extra-arachnoid injection of radiopaque oil.

A study of a total of 140 myelographic examinations via lumbar puncture revealed no constant anatomic or technical cause of extra-arachnoid injection. As a recent lumbar puncture was not a frequent factor it was felt that probably the greatest variable lay in the physicians doing the lumbar puncture. Placement of the spinal needle so that the bevel lies partially in both subdural and subarachnoid spaces will permit aspiration of cerebrospinal fluid and subsequent subdural injection of the medium into the space enlarged by cerebrospinal fluid leakage about the needle.

The authors' procedure includes the injection of a test dose of 0.5 to 1.0 cc. of pantopaque as soon as it is felt that a good needle position has been obtained. Upon tilting of the table, the pantopaque, which may be in several droplets, will flow freely in the subarachnoid space with a typical jerky or erratic tumbling motion. Abrupt changes in pressure of the cerebrospinal fluid with coughing will produce a rapid, bounding movement of the test dose. A crosstable lateral myelogram will show the medium to lie in one or several puddles, all of which will be of the same level. The dorsal margin will show a flat interface between the contrast medium and spinal fluid while the ventral surface of the column will follow the configuration of the anterior circumference of the arachnoid mater. Subdurally placed medium on the other hand, will appear as an amorphous or homogeneous sheet-like collection, and may flow for a considerable distance, but in a slow and ponderous manner. Changes in subarachnoid pressure with respiratory maneuvers will not significantly affect this motion. The flowing pantopaque may follow inconstant pathways and show inconsistent configuration. The lateral myelogram will almost invariably show it to be in the dorsal portion of the spinal canal, with the column fragmented and lying at different levels. The dorsal or ventral surfaces of the column usually will be undulating or irregular in contour.

The significance of subdural placement of medium lies mostly in its lack of recognition and subsequent attempt at interpretation which can easily be erroneous. The bizarre appearance may be interpreted as arachnoiditis or multiple spinal tumors, and large herniated lumbar disks can be missed, since the medium holds a dorsal position in the canal. Usually the subdural medium cannot be recovered. When significant amounts of residual contrast medium are present from previous studies serial lateral films,

checking the position of the test dose, are of great aid in avoiding further subdural instillation. If a test dose shows a subdural injection the examination can be attempted again within 2 or 3 days.

The authors feel that the physician who advances the needle steadily and promptly into the lumbar canal is much more likely to achieve a satisfactory placement than the operator who inches the needle gingerly forward, frequently withdrawing the stilet and rotating the bevel.—Donald N. Dysart, M.D.

Pauly, R., and Cools, M. Intérêt de la myélographie dans les lésions fermées du plexus brachial. (The value of myelography in closed lesions of the brachial plexus.) J. de radiol., d'électrol. et de méd. nucléaire, May, 1962, 43, 283–287. (From: Services de Radiologie et de Chirurgie de l'Hôpital Militaire de Liège, Belgium.)

The authors report 3 cases of traumatic herniation of meningeal sheaths with detachment or partial tear of nerve roots in the region of the brachial plexus. Murphy, Hartung and Kirklin were the first to report a case in 1947 (which they called traumatic meningocele and which they demonstrated during myelography). The lesion is due to traumatic stretching of the brachial plexus when the head and neck are forced away from the shoulder. Various degrees of nerve injury occur, depending upon the number of nerve roots involved, the extent of axonal tear, and the depth of avulsion of the root from the spinal cord.

Clinical, electromyographic and surgical diagnostic procedures are important. Myelography is easy to perform and more precise as to localization of herniation. The arachnoidal cysts (congenital, sometimes post surgical) are differentiated by demonstration of normal nerve root cuffings along such cysts, whereas in traumatic herniation the nerve root cuffing becomes a meningeal pouch, retaining contrast medium in the erect position.—J. N. Sarian, M.D.

#### SKELETAL SYSTEM

LICK, R. F., and VIEHWEGER, G. Ein Beitrag zur Diagnose der fibrösen Dysplasie des Knochensystems (Jaffé-Lichtenstein-Uehlinger): Eine röntgenologische und pathologischanatomische Studie. (Contribution to the diagnosis of fibrous dysplasia of the osseous system [Jaffé-Lichtenstein-Uehlinger]: roentgenologic and pathologic-anatomic study.) Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin, July, 1962, 97, 33–38. (Address: Dr. G. Viehweger, Chirurgische Universitätsklinik und Poliklinik, Röntgenabteilung, Würzburg, Germany.)

Polyostotic fibrous dysplasia is known to have a predilection for extremity bones. Rarely are carpal and tarsal bones, the spine and epiphyseal portions of other bones affected. A case which forms an exception is reported.

The patient was a 59 year old man. At the age of 18 he had suffered a spontaneous fracture of the right tibia and at the ages 37 and 38 spontaneous fractures of the left and right humerus, respectively. At 36, and again at 44 and 47 years of age he was treated for leg ulcers which became so severe that a leg amputation was necessary 12 years later. Postoperatively, another spontaneous fracture of the right humerus was encountered. Soon afterward the right lobe of the thyroid gland was resected for a nodular goiter. Two years later he succumbed to a sudden cardiac attack.

Far advanced fibrous dysplasia was found in the large tubular extremity bones. Of special interest was the epiphyseal involvement of several bones and a complete interruption of the cancellous portion of the radius, ulna and several phalanges. Several carpal bones, as well as a talus and metacarpals were also involved. The autopsy revealed cystic and mucoid degeneration of the fibrous bone marrow tissue. Coexisting skin tumors also showed similar changes histologically. Several pertinent roentgenographic reproductions and photomicrographs illustrate the findings.—Ernest Kraft, M.D.

Kushnick, Theodore, Paya, Kazem, and Mamunes, Peter. Chondroectodermal dysplasia: Ellis-Van Creveld syndrome. A.M.A. Am. J. Dis. Child., Jan., 1962, 103, 77-80. (Address: Dr. T. Kushnick, Department of Pediatrics, Seton Hall College of Medicine and Dentistry, Jersey City 4, N. J.)

Chondroectodermal dysplasia is not frequently reported and the authors add another case to the literature.

The patient had the clinical features of selective ectodermal dysplasia, polydactyly and chondrodysplasia. Chromosome studies were done by culturing and preparing peripheral leukocytes and these were analyzed by a modified Moorhead technique. Fourteen metaphase plates that could be counted had 46 chromosomes and no detectable morphologic alterations. The buccal sex chromatin test was positive.— John L. Gwinn, M.D.

BEYER, A., and STECKEN, A. Ossale Strukturveränderungen beim Klippel-Trenaunay-P.-Weber Syndrome. (Structural changes of bones in the Klippel-Trenaunay-P.-Weber syndrome.) Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin, July, 1962, 97, 45-51. (Address: Dr. A. Stecken, Mommsenstr. 32, Berlin-Charlottenburg, Germany.)

Partial gigantism associated with nevi, varices (Klippel-Trenaunay) and arteriovenous anastomoses (Park's-Weber) is rather rare, but coexisting osseous changes occur more frequently than is generally realized. A pertinent case of this kind is reported.

The patient was a 33 year old woman with nevi which had increased in size from early childhood until she was 20 years old. The lesions extended over the left hemithorax and the left upper extremity. Associated varicosities displayed systolic-diastolic action. The left forearm was 3 cm. longer than the right. Thus a classic Klippel-Trenaunay-P.-Weber syndrome was presented.

Roentgenologic examination revealed gross changes of the bones of the left upper extremity. Marked cystic changes were located in the distal third of the humerus, mostly in the marrow spaces, but also encroaching upon the cortex. The metaphyseal and epiphyseal portions were less involved, but coarse trabeculations extended downward to the distal portion of the radius and ulna. Of special interest was a marked widening of the channels of the nutrient arteries in the humerus, forearm bones and the third metacarpal midshaft. Multiple dilated vessels were noted in the compact portions of the radius and ulna. The left scapula and several ribs on the left side also revealed coarse trabeculation. Shallow indentations were noted on the undersurface of some ribs. All bones participated in the overgrowth as compared with the normal right side.

Partial gigantism, the outstanding finding of the syndrome, involves not only the bones but also the soft tissues. Although angiography was not permitted in their patient, the authors believe that aneurysmal dilatation of vessels led to the marked alteration of osseous structures as recorded in similar cases. Numerous roentgenographic reproductions illustrate the described changes of bones and vessels.—Ernest

Kraft, M.D.

WHITELAW, M. JAMES, THOMAS, SYDNEY F., Graham, William, Foster, Thomas N., and Brock, Clayton. Growth response in gonadal dysgenesis to the anabolic steroid norethandrolone. Am. J. Obst. & Gynec., Aug., 1962, 84, 501–504. (From: The Departments of Obstetrics and Gynecology, Radiology, and Surgery, O'Connor Hospital, San Jose, and the Department of Radiology, Palo Alto Clinic, Palo Alto, Calif.)

Until recently treatment of gonadal dysgenesis (Turner's syndrome) has consisted mainly in development of the secondary sex characteristics using an estrogen. Unfortunately this leads to an early closure of the epiphyses with a marked loss in final height. Attempts to induce growth in gonadal dysgenesis with human growth hormone have been discouraging.

The authors report a patient with Turner's syndrome treated for 22 months with an anabolic steroid (norethandrolone). An excellent response in growth resulted with no evidence of accelerated epiphyseal maturation.

It is concluded that failure to grow in this condition is not due to an insufficient or abnormal pituitary growth hormone. It is suggested that patients with gonadal dysgenesis be treated with an anabolic steroid until epiphyseal maturation is nearly complete, at which time estrogen therapy be initiated.— Eugene C. Klatte, M.D.

Kosowicz, Jerzy. The carpal sign in gonadal dysgenesis. J. Clin. Endocrinol. & Metab., Oct., 1962, 22, 949-952. (From: Second Department of Internal Medicine, Medical Academy, Poznán, Poland.)

Dorsopalmar roentgenograms were made of the hands and wrists in a neutral position in 37 cases of gonadal dysgenesis, or gonadal dysplasia, and also in 466 control cases. Osteoporosis was a common finding in gonadal dysplasia as well as an occasional case of Madelung's deformity. An abnormal shape of the bones of the proximal carpal row was found in many cases of gonadal dysgenesis, and the bones did not form a slight normal arch, but were angular in shape. The carpal angle was devised to more accurately study these cases.

The carpal angle is formed by drawing two tangents. The first one touches the proximal outline of the navicular and lunate bones, and the second one touches the triangular and lunate bones. The mean carpal angle in the control subjects was 131.5°, whereas in the gonadal dysgenesis cases it was 118°.

The carpal sign is a phrase used when the carpal angle is less than 107°. It was positive in 19 cases of gonadal dysgenesis. The carpal angle was less than 107° in 25 of the normal cases. A carpal angle above the mean normal value of 132° was not found in the gonadal dysgenesis patients.

The carpal sign occurred more frequently in cases of eunuchoidism and adrenal cortical hyperplasia than in normal subjects, but not as frequently as in cases of gonadal dysgenesis. The carpal angle was normal in cases of primordial dwarfism.

The decreased carpal angle in gonadal dysgenesis can be regarded as one of the many developmental anomalies.—Charles W. Cooley, M.D.

FOCHEM, K. Zum Carpaltunnelsyndrom. (The carpal tunnel syndrome.) Radiologia Austriaca, 1962, 13, 169-172. (From: Röntgenstation der I. Universitäts-Frauenklinik in Wien, Vienna, Austria.)

In the carpal tunnel syndrome the symptoms result from involvement of the median nerve. Abnormal anatomic changes, mostly due to injury, can cause the symptoms.

The author describes a technique which shows the tunnel adequately. The patient places his hand in dorsal flexion (about 60 degrees) on the cassette, with the central ray directed in the longitudinal axis of the middle finger. This view allows an accurate diagnosis of fractures, dislocations, subluxations, or other pathology, not always possible on routine views of the wrist.—Hans W. Hefke, M.D.

KARNO, MARTIN L. The iliac horn syndrome; a case report. J. Bone & Joint Surg., Oct., 1962, 44A, 1435–1438. (From: The Orthopedic Service, Ireland Army Hospital, Fort Knox, Ky.)

The author describes an ectomesodermal disorder affecting the nails, the ilia, and various joints. He does not mention the synonyms that this disease has previously been described under including osteo-onychodysplasia, arthrodysplasia, and Turner's syndrome.

The author reports one patient, a soldier in the service, with an iliac horn seen on roentgenograms as well as elbow and wrist deformities. He points out the association of deformities of the nails and the fact that this subject had siblings and a father who experienced similar anomalies. Roentgenographic reproductions substantiate the author's description of his patient.—David C. Alftine, M.D.

ABDALLA, M. A., and Nessim, F. Hereditary osteo-onychodysplasia; report of a case. J. Bone & Joint Surg., Oct., 1962, 44A, 1321–1330. (From: The Orthopaedic Service, Helmia Army Hospital, Cairo, Egypt.)

A single case of this syndrome is presented. This is a familial syndrome showing dysplasia of the fingernails, elbows, patellae, and iliac bones. Any or all of the deformities may be present and include thinning of the fingernails or shortened fingernails and toenails. If there is dysplasia of the pelvic girdle, it usually is manifested as iliac horns, coxa valga, or arching of the sacrum. Knees, elbows, and wrists are similarly affected with dysplastic changes. The symptoms causing the patient to seek medical attention are usually pain and discomfort in the knees and limitation of motion at the elbows.

Several photographs and roentgenographic reproductions accompany the article.—David C. Alftine, M.D.

Baclesse, F., Calle, R., Juster, M., and Laval-Jeantet, M. Osteosarcome du femur; étude microradiographique. (Osteosarcoma of femur; microradiographic study.) J. de radiol., d'électrol. et de méd. nucléaire, May,

1962, 43, 267-274. (From: Fondation Curie et Section de Microradiographie du Laboratoire de Physiologie du Travail, Paris, France.)

The authors are of the opinion that the gap between histopathologic and roentgenographic diagnostic methods of bone tumors is filled by microradiographic study of sections varying from 3 mm. to 50  $\mu$ . in thickness. A summary of microradiographic technique and significance of microphotography is given.

For histopathologic study, sections must be decalcified, whereas for microradiography they are not; hence the advantage of demonstrating granular calcifications and trabecular alterations in early stages of osteosarcoma by microradiography. Such a study will also show osteolytic and osteoblastic changes, destruction of cortex and soft tissue extension by the invasive pathologic tissues. Because of the avascular nature of articular cartilage, it is not invaded by neoplastic tissue, as can be demonstrated by microradiography.

A case of recurrent osteosarcoma of femur (after 11 years of apparent cure by two series of roentgen therapy) is presented with roentgenograms and several microradiographic sections from the pathologic metaphyseal region. These are discussed and compared with a normal femoral microradiogram and the diagnostic features are evaluated.—J. N. Sarian, M.D.

FORD, LEE T., and RAMSEY, R. H. Chondrosarcoma of the pelvis and shoulder girdle. South. M. J., Sept., 1962, 55, 901-906. (From: The Department of Orthopedic Surgery, Washington University School of Medicine, and Barnes Hospital, St. Louis, Mo.)

The authors report 4 patients with chondrosar-coma treated by regional excision. The tumor arose in the pubis in 2, in the ischium in 1, and in the scapula in the 4th. They believe that the chances for survival of these patients is essentially no less than had hind-quarter or forequarter amputations been performed. If the diagnosis can be made without biopsy, the patient probably has a better chance of survival. When this is not possible but needle biopsy shows chondrocytes, the pathologist can advise the surgeon to proceed at once with radical local surgery. This must include excision of the biopsy tract. No recurrences have yet been discovered in these 4 patients although only 2 have been followed more than 5 years.—Arthur E. Childe, M.D.

Brav, Ernest A. Traumatic dislocation of the hip: army experience and results over a twelve-year period. J. Bone & Joint Surg.,

Sept., 1962, 44A, 1115–1134. (From: Madigan General Hospital, Tacoma, Wash.)

This is a report of the end results of various methods of treatment of dislocation of the hip. There has always been considerable controversy as regards the primary method of treatment, and the duration of restricted weight bearing and the author summarizes the results of a number of series of cases which have been reported previously.

This study includes 523 hip dislocations in 517 patients; 457 posterior and 66 anterior. Eighty-five per cent were due to automobile accidents. The cases are divided into Type A, anterior dislocation, 13 per cent; Type I, posterior dislocation without fracture, 45 per cent; Type II, posterior dislocation with fracture of the posterior lip, 32 per cent; Type III, posterior dislocation with fracture through the acetabulum or femoral head, 11 per cent. A total of 264 dislocations was available for follow-up.

The poorest results occurred in Type III and the best in Type A. In Type A there is less disturbance of the blood supply, but 8.8 per cent developed avascular necrosis. Poor or fair results were noted in 23 per cent of this group who were allowed to bear weight in less than 12 weeks and in only 9.5 per cent who had protection for 12 weeks or more.

The severe Type III cases had uniformly poor results with avascular necrosis in 70 per cent, and fair or poor results in 72 per cent. Protection from weight bearing for 16 weeks did not prevent the changes of traumatic arthritis.

Avascular necrosis was noted in 69 (26 per cent) of the dislocations and of these, 11 had "excellent or good" results. The functional result and the patient's satisfaction do not always coincide with the roentgen changes. The authors suggest that roentgenograms be taken at 3 month intervals for at least 2 years, and that at the earliest sign of avascular necrosis, protection be provided to decrease deformity of the head and secondary arthritis. Secondary surgery should be based entirely on the patient's complaints.

Arthritis developed in 38 per cent of the patients, increasing from 9 per cent in Type A to 72 per cent in Type III. Second or third degree calcification occurred around the joint in II per cent and 24 per cent had a narrowed joint space.

Those reduced within 12 hours of injury had 22 per cent fair or poor results and 18 per cent avascular necrosis, and with reduction later than 12 hours these figures were 52 per cent and 57 per cent.

The author's recommendations based on these studies are early closed reduction, with open reduction only when this is unsuccessful or there is a loose fragment in the joint. In Type A and I, motion is started at 3 weeks with weight-bearing at 12 weeks. Type II and III should start motion at 6 weeks and weight-bearing not earlier than 12 to 16 weeks.—

Martha Mottram, M.D.

WINSTON, JOSEPH M., and HEWSON, JAMES S. Early roentgen diagnosis of tuberculosis of the hip in children. *Radiology*, Aug., 1962, 79, 241–249. (Address: Dr. Joseph M. Winston, Jeanes Hospital, Fox Chase, Philadelphia 11, Pa.)

The early roentgen diagnosis of tuberculosis of the hip in children is still very important, as new cases are being seen, and with the advent of the antibiotics a mobile joint may be salvaged and ankylosis prevented. The authors report 9 patients in 15 years with early tuberculous changes of the hip, with microscopic proof of diagnosis. In a review of the literature it was noted that both admitting and operative diagnoses were frequently incorrect when the true condition was early tuberculosis of the hip.

Tuberculosis of the hip is a sign of generalized disease, is due to a hematogenous spread, and accounts for 20 per cent of skeletal tuberculosis. It usually occurs before puberty, often is para-articular and involves the adjacent femur or acetabulum. The usual onset is gradual and insidious, often without a demonstrable source, and with a limp preceding pain. Stiffness, shortening of the leg, and muscle spasm may follow. Usually there is anorexia, malaise, and an evening rise in temperature of  $1\frac{1}{2}$ –2 degrees. Blood studies and the Mantoux skin test may be helpful in diagnosis.

Early roentgen changes include osteoporosis, rarefaction, or slight alteration in density of the upper femur or iliac bones. More advanced changes include erosion of the acetabulum, areas of cancellous bone destruction, widening of the zone of increased density of the acetabulum, herniation of the acetabulum, and periosteal proliferation. The primary location of the disease is most often in the acetabulum, followed by the head, epiphysis, and neck of the femur, with various combinations. Destruction usually takes place first at joint margins as the cartilage is slow to be destroyed. There may be indications of fluid in the joint and/or articular capsule swelling. Tuberculosis of the neck usually occurs as a localized area of destruction just distal to the epiphyseal line. Changes occur slowly; in the second year bone atrophy becomes more apparent, the femur is dislocated upward and laterally, the articular cartilage becomes destroyed, and there is more pronounced shaft growth disturbance. In the third year there is beginning repair.

Culture of aspirated fluid, biopsy of regional lymph nodes (iliac lymph nodes, not inguinal), or biopsy of the affected joint itself may give proof of diagnosis. The differential diagnosis includes Legg-Perthes' disease, nontuberculous infection, acute and chronic arthritis, congenital dislocation of the hip, and slipped epiphysis. These may be differentiated clinically and/or with roentgen examination. It is particularly important to note that tuberculosis does

not destroy weight bearing articular surfaces early.— *J. C. Moore*, *M.D.* 

Neviaser, Julius S. (Washington, D. C.) Arthrography of the shoulder joint; study of the findings in adhesive capsulitis of the shoulder. J. Bone & Joint Surg., Oct., 1962, 44A, 1321–1330.

Diodrast was used to outline the shoulder joint space in 261 clinical cases. Of these, 68 were autopsy studies. Sixty-four were also exposed by operation.

The author describes the technique which seems quite simple and straightforward. The procedure appears to be of value in the frozen shoulder syndrome, but other conditions were of definite interest as well. Several roentgenographic reproductions are included to demonstrate the findings.—David C. Alftine, M.D.

#### BLOOD AND LYMPH SYSTEM

CARON, J., and BONTE, G. La phlébographie azygos. (Azygos phlebography.) J. de radiol., d'électrol. et de méd. nucléaire, May, 1962, 43, 259–266. (From: Service d'Électroradiologie Ouest, Hôpital Régional, Cité Hospitalière, Lille, France.)

Schematic drawing, brief description of the azygos venous system, phlebographic techniques and a few illustrative phlebograms are presented. In the experience of the authors, the simplest and safest technique is by injection of contrast medium into the posterior part of the 10th rib (on the right or on both sides simultaneously). If this is not possible, then injection into the spinous process of L-1 is easy to perform and phlebograms are usually satisfactory. A more complicated and less reliable technique is by injection into the inferior vena cava.

Diagnostic usefulness of such phlebograms is summarily discussed as to bronchopulmonary neoplasms, cancer of esophagus, various mediastinal tumors compressing the superior vena cava, decompensation of heart, constrictive pericarditis, and enlargement of left atrium. In portal hypertension, because of increased venous pressure and more rapid venous flow, there is dilution of the contrast mediand poor visualization of the azygos venous syst. However, the arch of azygos is often clearly dem strated. In case of ligation of the inferior vena c. (for cardiac decompensation) the azygos system at the spinal (meningeal) venous plexuses are extremedilated as demonstrated by transcostal phleb raphy. Thus their importance in the vicarious collateral venous circulation is evidenced.—J. Sarian, M.D.

Seventy-six examinations performed in the V toria Hospital, London, Ontario, using Selding technique of percutaneous arterial puncture a catheterization are discussed.

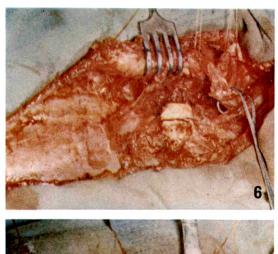
Fifty-nine catheterizations were by the femoroute and 17 by brachial puncture. The auth recommend taking a test roentgenogram in ev case following the injection of a small amount opaque medium.

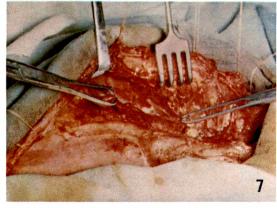
There are complications to the procedure. Coplete failure to puncture the artery occurred only i cases, all of these involving the brachial artery. Fapassage of the guide wire into the vessel wall occur in 5 cases and is considered the most important hazard of the procedure. It is stressed that cat ters may be passed easily and a good flow of blomaintained even though the catheter is dissecting vessel wall. One case developed severe vascus spasm distal to the puncture. Minor delay in retrof pulse distal to the puncture occurred in 3 cas. While some degree of hematoma formed in every case, hematoma of a size requiring specific thera occurred but once, due to sympathetic block.

The authors' opinion is that Seldinger catheterition is not the procedure of choice for visualization occlusive vascular disease distal to the lumbar aor Most difficulties experienced were in the group whalready suffered severe arterial change.—Eugene Klatte, M.D.



#### CONGENITAL ELEVATION OF LEFT SCAPULA (continued)









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Figua trapeza insertic

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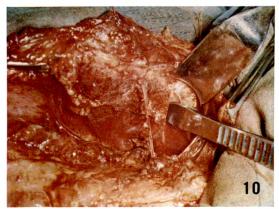
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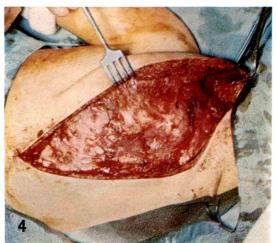


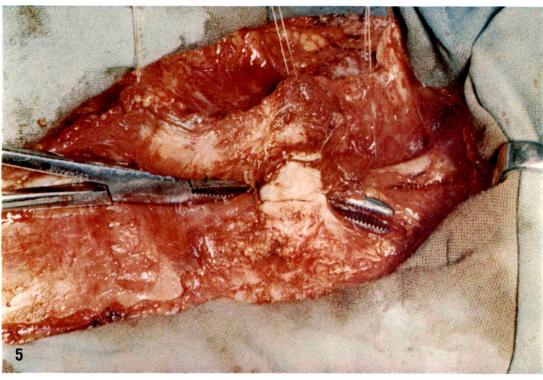
**Figure 2.** Supine view showing elevated contour of left shoulder. Note abnormality in preoperative radiograph (Figure 1).

**Figure 3.** Left paravertebral incision, cervicothoracic region (patient in prone position with head turned partially to the left).

**Figure 4.** Lateral retraction of mobilized skin and subcutaneous flap to show scapula and scapulothoracic musculature.

**Figure 5.** Trapezius and part of rhomboids detached at midline and retracted (in sutures) to show omovertebral bone.





FOR FURTHER STEPS IN SURGERY-TURN PAGE.

## Congenital Elevation of Left Scapula

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**Figure 1.** Preoperative radiograph indicates malformation of vertebral column and elevation of left scapula.

- **▶ 6.** The scapulo-omovertechondrosis has been divided teld open by retractor.
- 7. Demonstration of lower s magnus insertion into . (Omovertebral bone has moved.)
- 8. Detail of upper serratus insertion.
- 9. Elevation of upper is to show levator scapulae
- **10.** After division of close to its insertion, scapula nately mobilized from chest
- 11. Scapula, held by an now be drawn down and place by suture of the lower s 2-3 cm more distally than all position.
- 12. Postoperative radioshows appearance after on.



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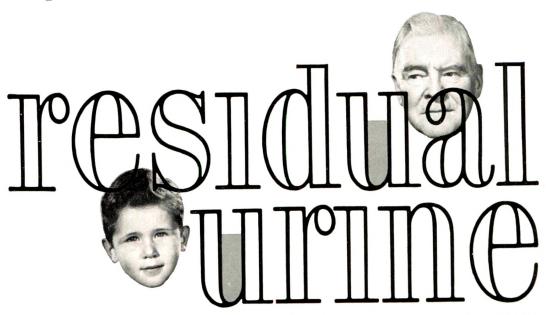
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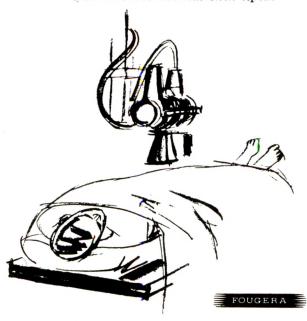


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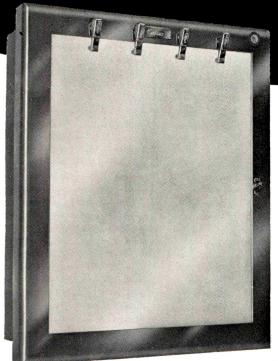
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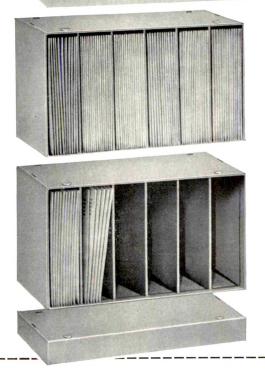
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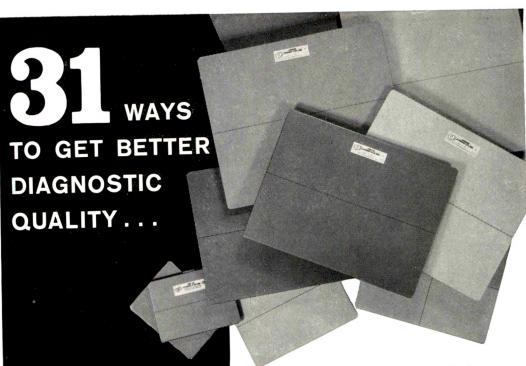
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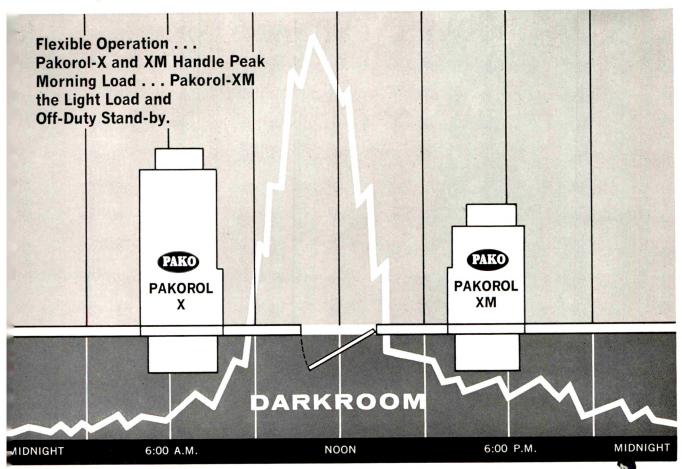
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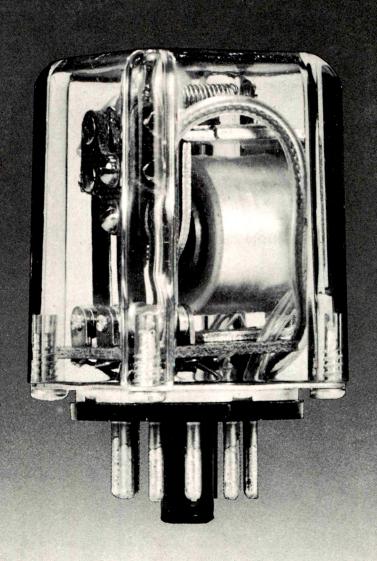


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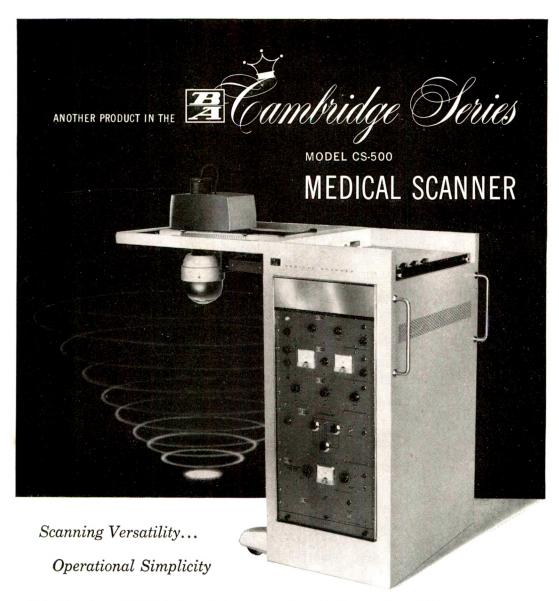
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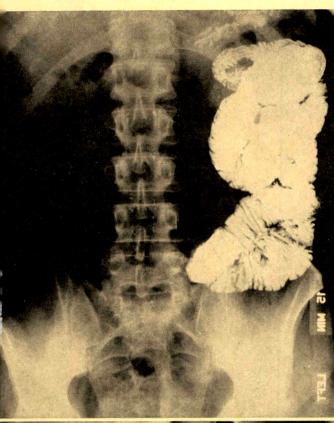
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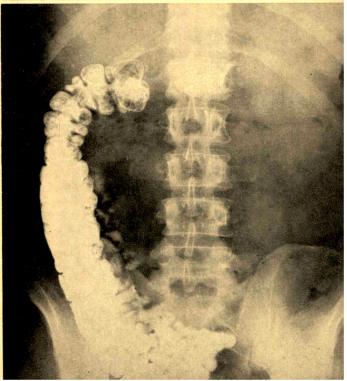
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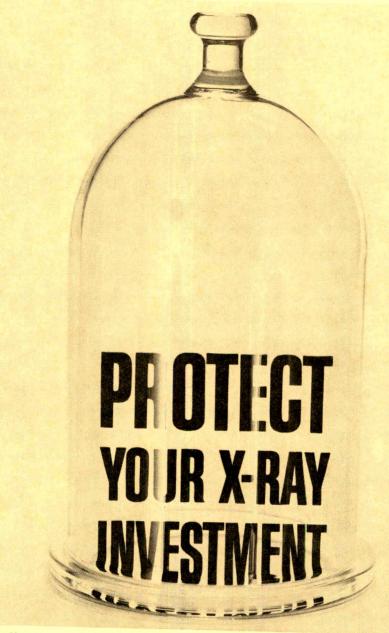
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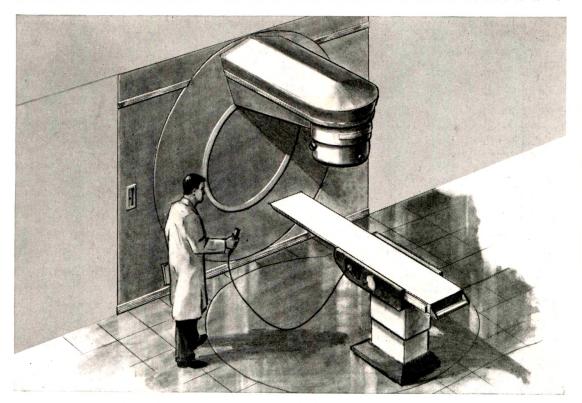
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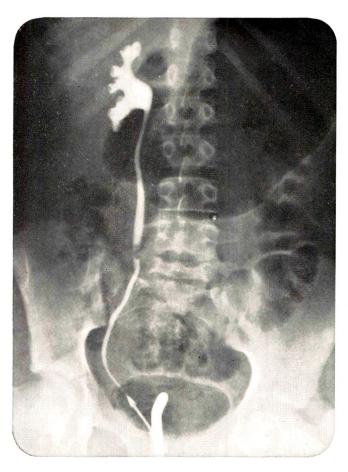
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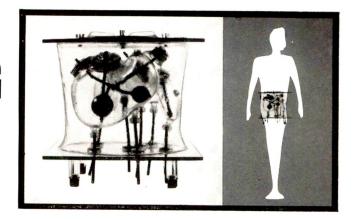
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#### NON-OPAQUE FOREIGN BODIES IN THE ESOPHAGUS

by Mrs. Mary Beth Frazer, R.T. Marshall, Missouri

Pathological obstruction and obstructions caused by metallic or opaque foreign bodies in the throat and esophagus are readily visualized by routine films of this area or are outlined by the flow of barium sulfate suspension around the object.

Occasionally a patient complains of persistent pain and difficulty in swallowing even though routine films and ordinary esophagus visualization with barium fail to reveal a foreign body. A review of the patient's recent meals may indicate the object—such as a chicken or fish bone. Normally this would lead to a tedious physical or surgical exploration by the nearest otolaryngologist.

But now a very simple but unique examination has proven very effective in visualization of non-opaque foreign bodies in the throat and esophagus. The procedure causes no injury to the patient and saves time in localization of the object.

Ordinary films should first be taken for comparison purposes. A tiny wisp of cotton is then placed in a teaspoon of barium sulfate suspension. Care should be taken to make a cotton wisp the patient

does not have difficulty swallowing. The patient is instructed to swallow the barium-soaked wisp, then given a small swallow of barium to help wash the cotton down. This should be done slowly and evenly to keep the cotton from washing down completely. Standard esophagus views using the Potter-Bucky diaphragm are then taken. The patient is placed either prone or upright in the left anterior oblique position. The left side is down with the right side elevated at approximately a forty-five degree angle. With breath suspended an exposure of 200 MA, 75 Kv. p., 3/10th second, Par Speed screen, at a 36inch distance, is used. The barium-soaked cotton will usually snag on any protruding fragment of bone, giving an excellent picture of the non-opaque object's location (see plate A). The bone in Plate B was removed from the esophagus by the otolaryn-

The simple procedure outlined here had proven a diagnosis so the specialist could proceed immediately with a plan of treatment.

Plate A



Plate B



#### A CLAMP TABLE FOR INFANTS

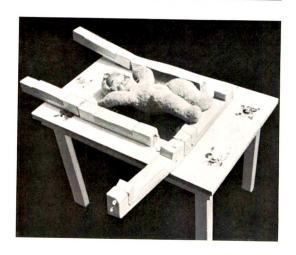
by Robert E. Canova X-ray Department DeKalb Public Hospital DeKalb, Illinois

Getting routine 72 inch A. P. and lateral chest films of newborn children can be a real problem. But a simple clamp table, convenient in design and inexpensive to make, can be a splendid solution.

The table shown here (see photo) is 18 inches high, made with a slot in the center for an 8 by 10" cassette. There are two sets of 2" square boards that act as clamps for the child's arms. Each of these boards has a 1" slot in it, lined with foam rubber to cushion the child's arms as they are held outstretched.

There are also two 2 by 4" boards, again lined with foam rubber, which hold the child's feet (these are more commonly used only with older children).

All these clamps are hinged and fasten with simple hooks and eyes. You will notice that two eyes have been provided for each hook. This makes it easy to adjust the clamps on extremities of varying thickness.



The A. P. film is taken by laying the baby on the 8 by 10" cassette and closing the clamps. The lateral film of a newborn is made by laying him on his side with his underarm pulled behind him. The upperarm is held behind by folding the blanket over, behind and around the arm, then stuffing the blanket between the arm and body. This gives an excellent lateral view.

This clamp table was designed and built, with the help of our Radiologist, W. O. Thompson, M.D., using simple tools and a few dollars' worth of ordinary hardware. It reduces frustration, speeds the examinations and—most important of all—gets excellent results.

#### A COMPREHENSIVE TRAFFIC CHART

by Raphael R. Alvarado, R.T. (ARXT) Chief Technician Theodore A. Ketcham, R.T. (ARXT) Senior Technician Memorial Hospital New York, New York

With this design for a traffic chart you have a simple, effective way to follow the flow of work, the location of personnel, the availability of examination rooms and equipment.

First, you line a simple chart, following the pattern shown here (see photo) but adapting it to your own number of rooms and your room numbers. From this you can easily get an enlarged photocopy or photo print, of a size that is easy to read and convenient for writing upon.

Take your enlarged photocopy or print and frame it as a picture behind glass. At a strategic location you hang it on the wall or hold it on with molly-screws through the frame moulding.

Now you can record information with ordinary china marking pencils—red, black or in combination—and your

traffic chart can easily be wiped clean at the end of each day. You have a permanent, businesslike "information center" that keeps everyone informed quickly and with minimum effort.





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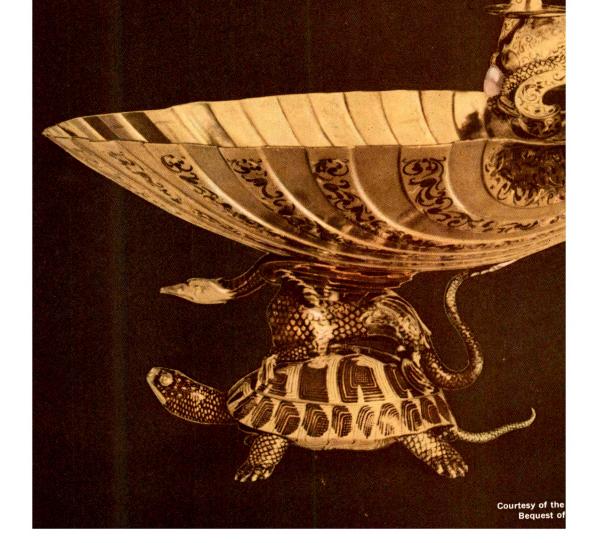


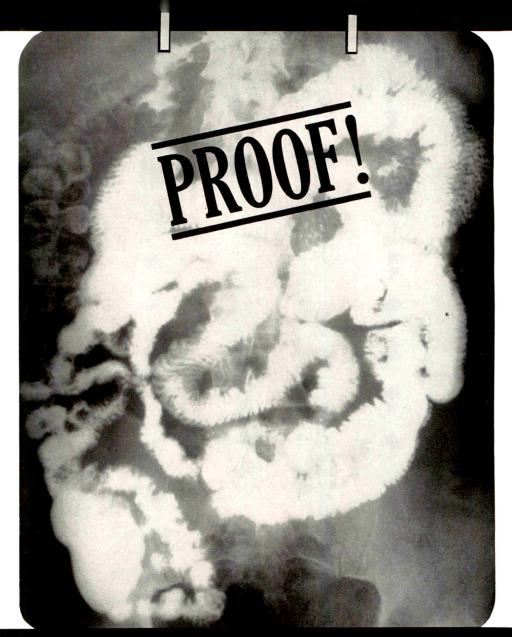
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Hytrast appears to be slightly more irritating to bronchial mucosa than oily media, but less so than other previously used aqueous preparations. A transient temperature elevation has been observed particularly where alveolarization inadvertently occurs and elimination is delayed. Consult the product brochure for complete information on administration, side effects, contraindications, and precautions.

Hytrast is supplied in 25 ml. vials containing 20 ml. sterile aqueous suspension: 50% w/v of combined iodine as a mixture of N (2, 3-propyldiol) -3, 5 diiodopyridone -4 and 3, 5 diiodopyridone -4.

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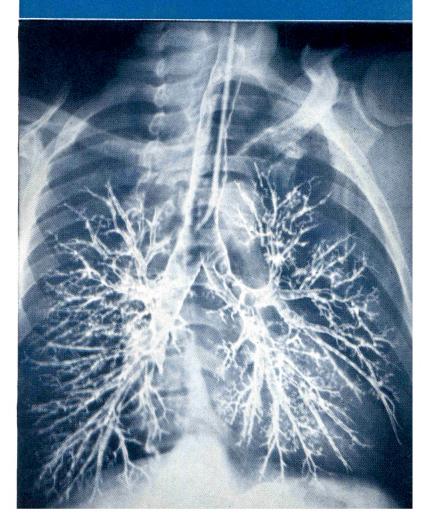
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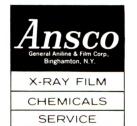
with Ansco High-Speed film  $processed \ in$   $Liquamat^{\circledast} \ Chemicals.$ 

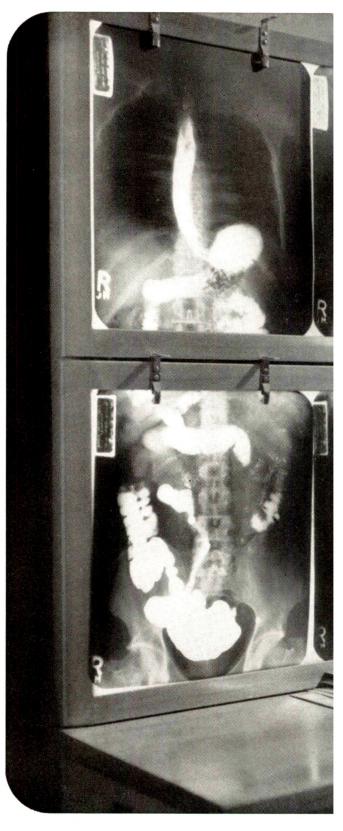
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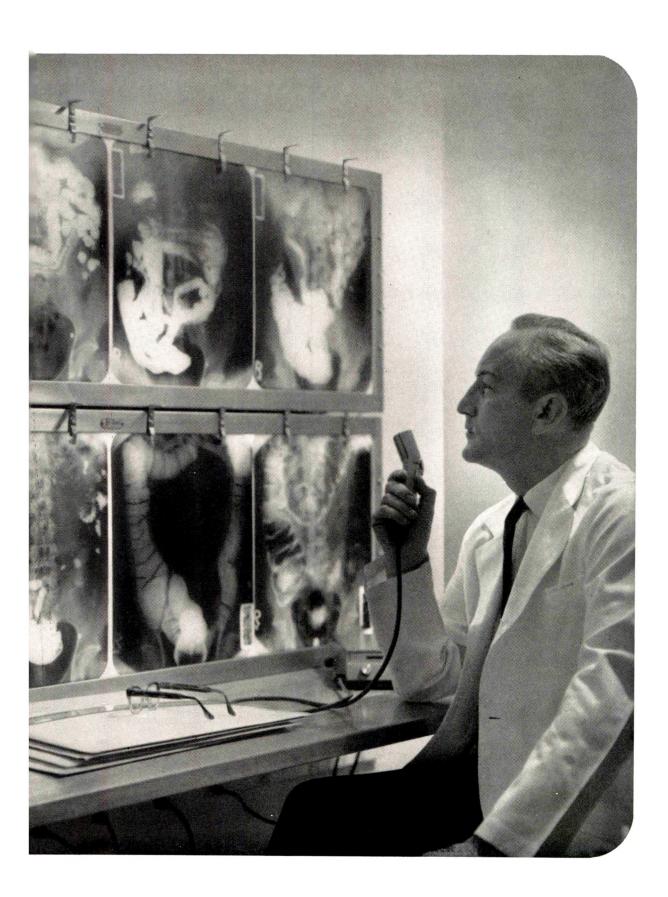
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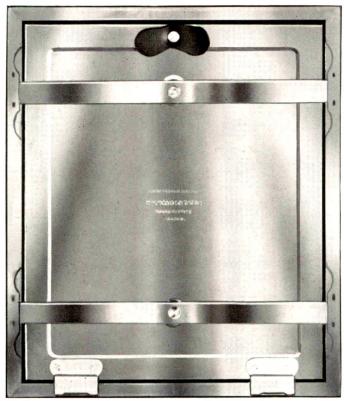




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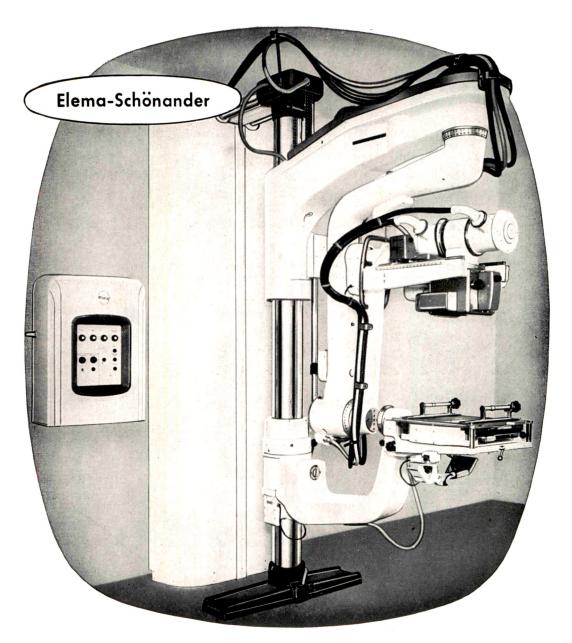
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readily absorb moisture, therefore does not tend to warp; neither does it require any extra exposure.



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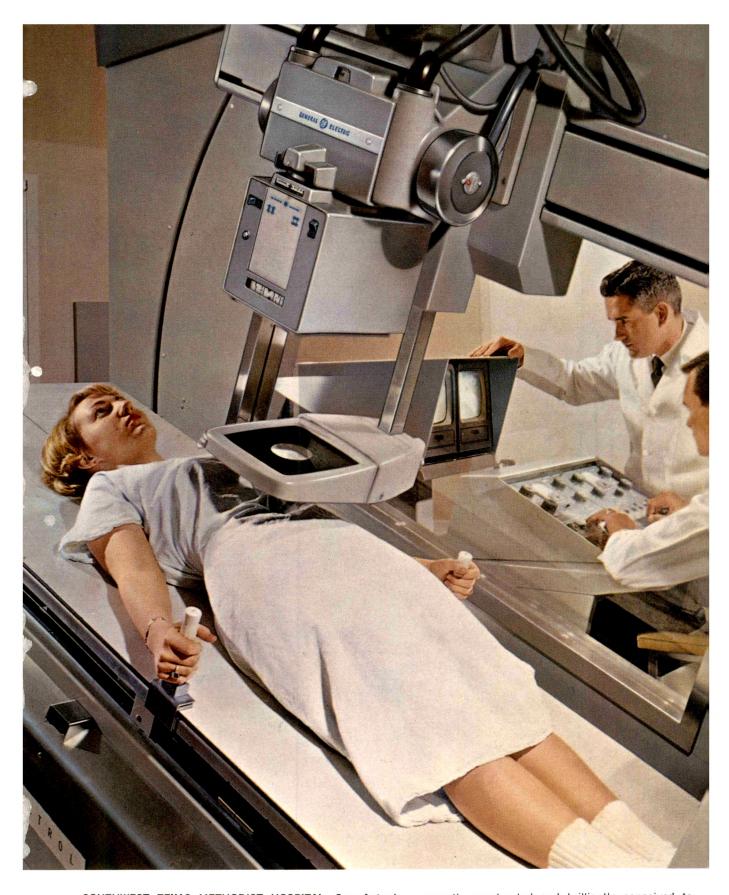
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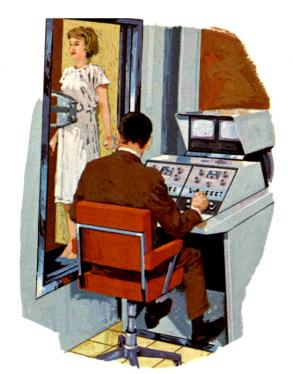
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# General Electric Teletrol... your "front window" on today's revolution in radiology

Who would imagine this radical new concept in diagnostic x-ray would gain acceptance so rapidly? General Electric TELETROL System—remote-control fluoroscopy and radiography—revolutionizes the radiologist's whole viewpoint—both figuratively and literally. Combines remote, radiation-free control of equipment and patient positioning, with all the most sought-after technical developments of recent years: electronic image intensification ... remote television viewing in consultations ... and cinefilming as well as routine radiography with cassettes. Although no longer the only remote unit, G-E TELETROL continues to overshadow the others with inherent advantages that no comparable alternative approach can offer—1.



SOUTHWEST TEXAS METHODIST HOSPITAL, San Antonio — recently constructed and brilliantly conceived to take full advantage of technological innovations in every phase of operation. General Electric TELETROL remote-Control X-Ray System is the diagnostic hub of the impressively equipped Department of Radiology, second to none in planning for present and future needs.



#### New concepts — physically and psychologically

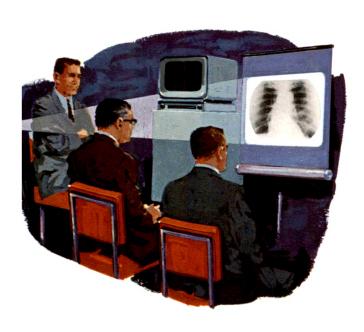
TELETROL Remote-Control Diagnostic X-Ray does away with the problems and discomforts of wearing lead protective aprons, gloves, dark-accommodation goggles. Takes your patients out of the dark, into a far more pleasant form of fluoroscopy. And the radiologist governs both x-ray table and patient by means of positioning controls right on the operating console. Integral power-palpator — also operating from the console — features automatic pressure cutout, insuring "just the right touch."



#### Fluoricon image intensification

The highly advanced Fluoricon image intensification system in TELETROL lets you work in normal room illumination. Diagnostic images then are presented on the tv monitor at the control console, enhanced by video-circuit amplification. A second television screen can be added for simultaneous sight-monitoring of patient, or remote reading of patient films transmitted from darkroom or file room. TELETROL also is an ideal tool for teaching and consultations; will feed images directly into any existing or anticipated hospital closed-circuit television system.





#### Remote-control cinefilming and radiography

TELETROL lets the radiologist do 16-mm cinefilm recording simply by pushing a button on the control console. Here is reliability and simplicity that makes motion recording during fluoroscopy just as practical as spot filming! The image-brightness is locked electronically, for unfailing results. And you can electively make conventional exposures, using cassettes up to  $14 \times 17$  size. The image pickup tube in the table, and the x-ray tube above, will automatically track each other in precise alignment; cassette tray also remotely power-propelled into position.





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TELETROL is a comprehensive system integrating today's most advanced x-ray concepts. Includes 180° angulating table with 30" longitudinal and 10" lateral power travel; remote-control console; x-ray generator;

9" image intensifier; 16-mm synchronous film camera; tv camera; 8" tv monitor; automatic brightness control; pulsing system; heavy-duty x-ray tube (0.75-2.0-mm effective focal spots); powered rotating footrest.

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opens entirely new techniques of in vivo micro dosimetry in radiation therapy and in evaluation of diagnostic procedures. It provides simple . . . precise . . . reliable . . . localized, multiple point dosimetry of X-rays, gamma rays, betas, fast neutrons and protons.

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Internally administered radio-isotopes Dose determinations during fluoroscopic and radiographic procedures

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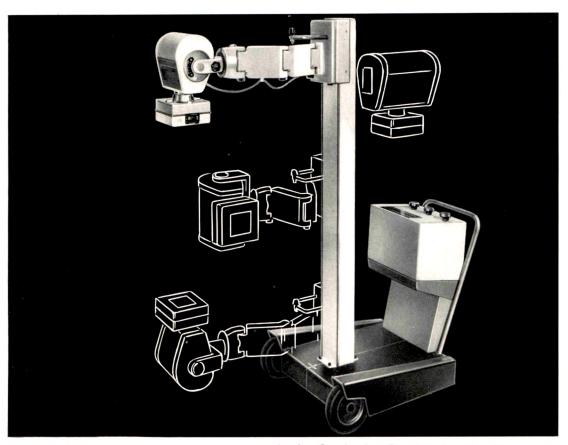
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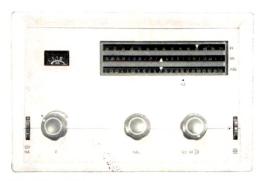
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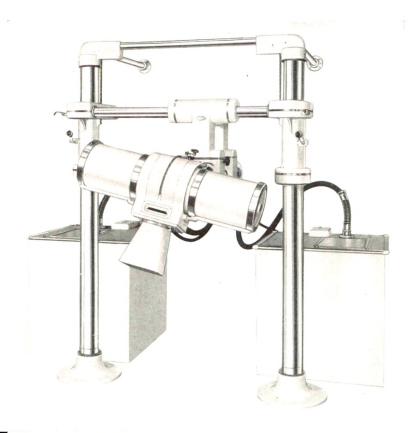
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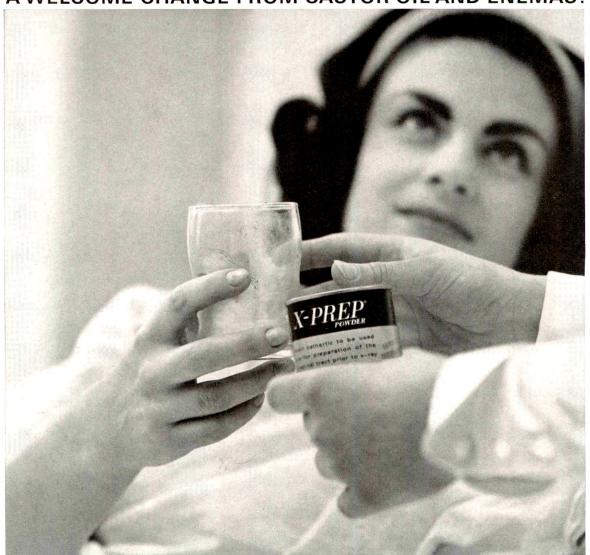
Reference: Steinbach, H. L., and Burhenne, H. J.: Performing the Barium Enema: Equipment, Preparation, and Contrast Medium. Am. J. Roentgenol. 87:644, 1962.

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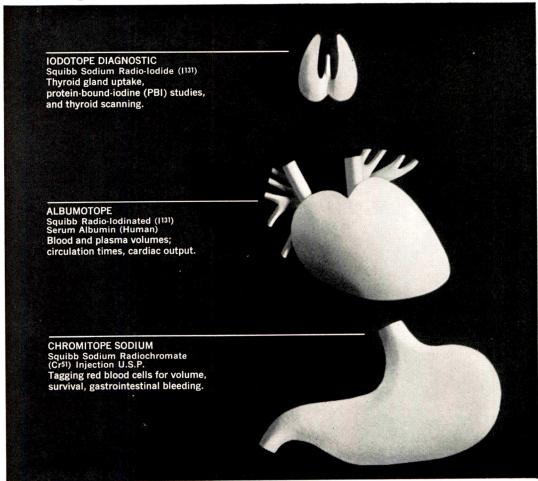
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REFERENCES: 1. Statman, A. J.: Am. J. Gastroenterol. 33:740 (June) 1960. 2. Murphy, T. E.: J. Urology 86:659 (Nov.) 1961. 3. McGrattan, V. T.: J. Abdominal Surgery 3:178 (Nov.) 1961. COMPOSITION: X-PREP Powder is a deliciously cocoa-flavored, purified and standardized senna concentrate.

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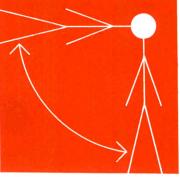
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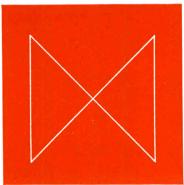


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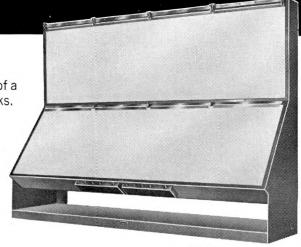
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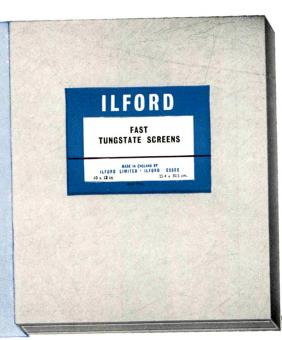
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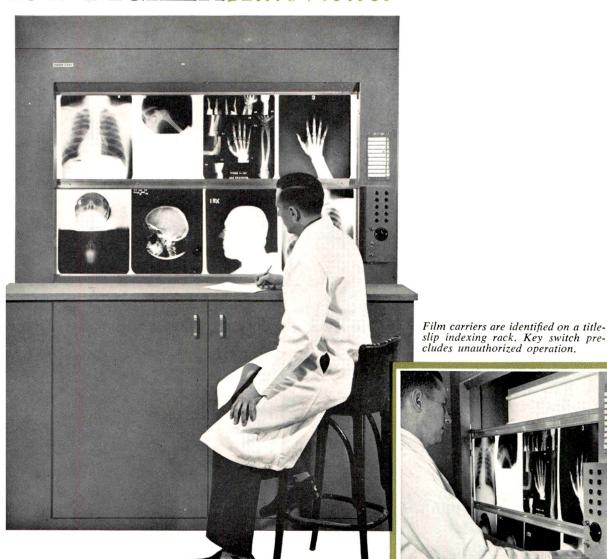
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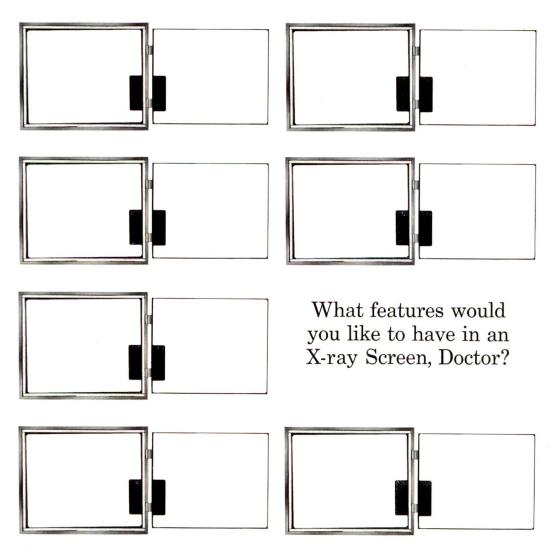
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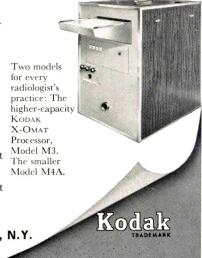
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#### RADIOGRAPHY OF INFANTS AND CHILDREN

By Donald B. Darling, M.D.

Tufts University School of Medicine
Boston, Massachusetts

With the Technical Assistance of James M. Anthony, R. T. Children's Hospital of Pittsburgh Pittsburgh, Pennsylvania

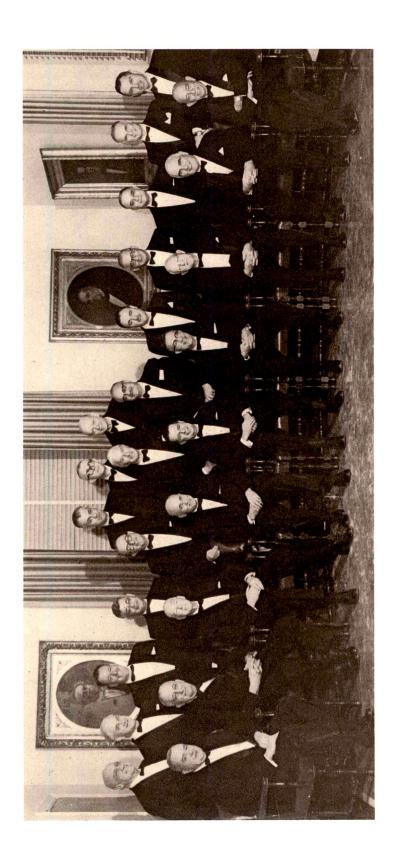
Doctor Darling's book should be welcomed by all those concerned with the problems of satisfactory radiological examinations of younger patients. He discusses here and portrays in detail MAJOR TECHNICAL PROCEDURES commonly used. The text is divided into two major divisions. The first describes and illustrates the equipment employed in radiography and fluoroscopy and presents methods of eliminating radiation exposure to personnel and minimizing that to the patient. The second section covers each examination in detail with one chapter devoted to infants and another to children. Dec. '62, 212 pp., 456 il. (Amer. Lec. Roentgen Diagnosis edited by Lewis E. Etter, Western Psychiatric Institute and Falk Clinic), \$16.50

#### TECHNOLOGICAL NEEDS FOR REDUCTION OF PATIENT DOSAGE FROM DIAGNOSTIC RADIOLOGY

Edited by Murray L. Janower, M.D. Massachusetts General Hospital Boston, Massachusetts

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- MODERN RADIOLOGY IN HISTORICAL PERSPECTIVE by Stephen B. Dewing, New York Univ., New York City. Aug. '62, 200 pp., \$5.75
- MEDICAL RADIOGRAPHIC TECHNIC (2nd Ed., Rev. 2nd Ptg.) Prepared by The Technical Service Dept., General Electric X-Ray Corp. Under the original editorial supervision of the late Glenn W. Files. Revision by William L. Bloom, Jr., John L. Hollenbach, James A. Morgan, and John B. Thomas. June '62, 398 pp., 493 il., \$11.00
- RADIATION THERAPY IN THE MANAGEMENT OF CANCERS OF THE ORAL CAVITY AND OROPHARYNX by Gilbert H. Fletcher and William S. MacComb. Physics Section by Robert J. Shalek and Marilyn Stovall. All of Univ. of Texas M. D. Anderson Hospital and Tumor Institute, Houston, Texas. Jan. '62, 408 pp., 346 il. (Amer. Lec. Radiation Therapy), \$16.50
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- INTRAVENOUS CHOLANGI-OGRAPHY: A Concept of Interpretation by Robert E. Wise, The Lahey Clinic, Boston, Mass. July '62, 160 pp. (8½ × 11), 121 il. (Amer. Lec. Roentgen Diagnosis), \$9.50



Fiftieth Anniversary New York Roentgen Society November 19, 1962

The following are the Past Presidents who attended: First Row (seated) left to right: William Boone, Arthur Bendick, John Masterson, Ross Golden, speaker of the evening, Albert Dunn (President), Theodore Wachowski, Loomis Bell, Maurice Lenz, Maurice Pomeranz. Second Row (standing) left to right: Robert Ball, Harold Jacox, John Evans, Bernard Wolf (Vice President), Harold Jacobson, Philip Allison (Nuffield Professor of Surgery, Oxford, England), speaker of the evening, Frank Borrelli, Max Poppel, Henry Taylor, Jack Fried, Sidney Rubenfeld, Fred Ruzicka (Treasurer). Third Row left to right: William Seaman, James Nickson (Secretary), and Irving Schwartz.

# THE AMERICAN JOURNAL OF ROENTGENOLOGY RADIUM THERAPY AND NUCLEAR MEDICINE

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#### THE TRISOMY 17-18 SYNDROME\*

ROENTGEN FEATURES

By JOHN E. MOSELEY, M.D., BERNARD S. WOLF, M.D., and MARVIN I. GOTTLIEB, Ph.D., M.D.

NEW YORK, NEW YORK

THE recent explosive developments in medical genetics require more than a peripheral interest from clinical radiologists. Following the demonstration by Tjio and Levan<sup>16</sup> and by Ford and Hamerton<sup>5</sup> in 1956 that the normal human chromosome number is 46 rather than 48, as previously considered, there has been a remarkable series of investigations concerning the relationship of chromosomal abnormalities to various clinical conditions. Several abnormal sex chromosome patterns have been discovered including those responsible for the chromatin-positive Klinefelter's syndrome and for gonadal dysgenesis (Turner's syndrome). A strong stimulus was provided for this field of investigation in 1959 when Lejeune, Turpin and Gautier8 found an extra autosome (non-sex chromosome) in each of several cases of mongolism (Down's syndrome). Confirmation of this observation has established mongolism as the first recognized condition of autosomal trisomy in man. Since then, two new syndromes, due to a simple numerical abnormality of the autosomes, have been described. In both of these, as in mongolism, one chromosome exists in triplicate (trisomy) rather than as a normal pair so that the total number of chromosomes in the affected individual is 47 (Fig. 1). In mongolism, the extra chromosome is due to trisomy of chromosome 21 or 22. Patau and his collaborators<sup>10</sup> were first to describe an autosomal trisomy syndrome in which the extra chromosome was one of the medium-sized acrocentric autosomes of the group 13-15. Additional cases with this numerical autosomal abnormality have been reported1,9,15 and trisomy 13-15 has been established as a definite clinical entity. Edwards and associates4 and Smith et al.13 independently described cases in which trisomy of a chromosome of the group 17-18 was demonstrated. Their descriptions have been followed by several reports2,6,7,14,17,18 which leave little doubt that trisomy 17-18 is a recognizable clinical syndrome.

Numerical abnormalities of the human chromosomes are generally considered to be

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due to a mechanism known as nondisjunction. This abnormality of cell division involves the failure of newly divided chromosomes to migrate to opposite poles of the spindle. They remain together and migrate to one pole. The daughter cells, therefore, contain an unequal number of chromosomes. In order for this abnormality of chromosome number to be present in all the cells of an individual, nondisjunction must take place during early division of the zygote or during meiosis of the parental germ cells.

The paucity of distinguishing structural features of chromosomes in some groups of the human karyotype has resulted in the difficulty of determining exactly which chromosome is present in triplicate and has led to some problems regarding the names to be applied to trisomy syndromes. Edwards et al.4 considered the condition referred to in this report as trisomy 17-18 syndrome to be due to trisomy of chromosome 17. Smith et al.13 consider it to result from trisomy of chromosome 18. Because present cytologic techniques do not permit a more accurate chromosome identification, the designation trisomy 17-18 syndrome has come into general use. A plea has been made, however, to accept the triple chromosome as chromosome 17, regardless of the uncertainty of identification, acknowledging the priority of the descriptions by Edwards et al. and in order to simplify the nomenclature.3,7

#### CLINICAL SYNDROMES

The presence of an extra chromosome causes a genetic imbalance which, in the three autosomal trisomies so far described, results in certain patterns of developmental disturbance which are sufficiently characteristic to form clinically recognizable syndromes. The anomalies resulting from trisomy of chromosome 21 or 22 (mongolism) are well known. The characteristic features of the trisomy 13–15 syndrome include eye defects (anophthalmia, microphthalmia, coloboma), cleft palate, hare lip, polydactyly, trigger thumbs, capillary

hemangiomata and congenital heart disease.

The distinctive anomalies of the trisomy 17-18 syndrome appear to be more constant than those of the other two autosomal trisomies. Many of the defects can be demonstrated roentgenographically and when seen in combination provide a basis for roentgen recognition of this syndrome. In practically all reported cases, the patients have been classified as mentally retarded. The duration of life has ranged from 2 days to 16 months and in some cases has been too short to permit an unequivocal estimation of mental development. The most constant abnormalities have been: (1) low set, misshapen ears; (2) receding chin; (3) small triangular mouth; (4) shield-like chest; (5) hypertonia; (6) abnormalities of the fingers and toes; and (7) cardiac malformations which regularly include interventricular septal defect and patent ductus arteriosus.

The parents of these infants are usually of a relatively advanced age. A mean maternal age of 34.8 years has been found in the reported cases. The mean maternal age found in mongolism is 33.5 years. <sup>12</sup> In all patients there has been a definite failure to thrive. This has been most apparent in the postnatal failure of growth and maturation. The infants are significantly small at birth and it is likely that failure of growth and maturation begins sometime during fetal life, probably during the last trimester. <sup>14</sup>

A number of less constant anomalies have been found in this syndrome. Some of them will be discussed later in this paper. All of them and their relative frequencies are tabulated in the reports of Smith *et al.*, <sup>13,14</sup> Gottlieb and associates, <sup>7</sup> and Uchida *et al.* <sup>18</sup>

Three proven cases of trisomy 17–18 syndrome have been seen recently at our hospital. In all 3 cases the probability of a chromosomal abnormality was suggested by a complex of clinical and roentgen anomalies. The clinical aspects of these cases have been reported by Gottlieb and associates.<sup>7</sup> In this communication the charac-

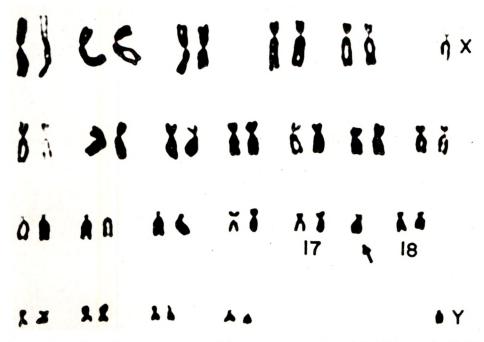


Fig. 1. Case II. Karyotype. Twenty-two pairs of chromosomes are shown in addition to the X chromosome (marked X) and the Y chromosome (marked Y). The extra chromosome (arrow) is inserted between pairs 17 and 18. The total number of chromosomes is therefore 47 or one more than the normal complement. It is not possible to determine whether the extra chromosome belongs to pair 17 or 18.

teristic roentgen features will be demonstrated and discussed.

#### CASE REPORTS

CASE I. The patient, a white female, was born in August, 1961. She was the seventh child of a 43 year old mother and father. Gestation was 43 weeks. At birth the infant weighed 5 pounds, 9 ounces. During the immediate newborn period, she had marked respiratory distress and was transferred to The Mount Sinai Hospital with a diagnosis of pneumonia. On admission a chromosomal abnormality was suspected because of the following complex of anomalies: low set and malformed ears, right hare lip, high arched palate, depressed nasal bridge, receding chin, shield-like chest with wide spaced nipples, flexion deformities of the fingers and a loud systolic murmur.

Roentgen skeletal studies were performed at 3, 12, 13 and 15 weeks of age. These revealed hypoplasia of the mandible with relative overbite of the maxilla. The posterior fossa of the skull appeared increased in its anteroposterior diameter (Fig. 5). The heart was considerably enlarged and the pulmonary vascular markings

were increased. The ribs appeared unusually thin (Fig. 7). The pelvis was small and its relatively small proportion in relation to the thorax was striking. The distal femoral ossification centers were small and poorly mineralized. The proximal tibial epiphyses were unossified (Fig. 8). Both hands showed ulnar deviation. The fingers were held in flexion, the second finger overlapping the third. When the fingers were straightened out, the third, fourth and fifth fingers were deviated to the ulnar side resulting in increased spacing between the second and third digits (Fig. 2). There was an equinovarus deformity of both feet. The middle phalanges of the third, fourth and fifth toes were unossified. The big toes were distinctly shorter than the second toes (Fig. 4A).

Blood chemistries, blood cultures and cerebrospinal fluid analysis revealed no abnormalities. The patient was obviously retarded. She did not smile, was unable to hold her head erect and could not roll over. There was no response to auditory or visual stimuli. She was treated for congestive heart failure and pneumonitis but died 105 days after birth. Since birth she had gained only 200 gm. Chromosomal analysis was



Fig. 2. Case 1 at 13 weeks of age. The fingers have been flattened against the table by a tongue depressor. Nevertheless the ulnar deviation of the hand is not artifactual. The third, fourth and fifth digits are deviated to the ulnar side producing increased spacing between the second and third fingers. There is persistent flexion of the second finger at the proximal interphalangeal articulation. The middle phalanx of the fifth finger and the first metacarpal are hypoplastic.

performed from peripheral blood mononuclear cell cultures. The method used was a modification of that of Hungerford. All cells examined had 47 chromosomes with 5 chromosomes in the 17–18 group. It was not possible to determine with certainty whether the extra chromosome was 17 or 18.

CASE II. The patient, a Puerto Rican male, was born prematurely at The Mount Sinai Hospital in September, 1960. He was the fourth child of a 36 year old mother and a 39 year old father. Because of respiratory distress, which developed shortly after birth, the patient was transferred to the premature nursery. On examination, the possibility of a chromosomal abnormality was suspected because of the following complex of anomalies: low set and posteriorly rotated ears, small receding mandible, "fish-like" mouth, high arched palate, shieldlike chest with wide spaced nipples, flexion deformities of the hands, second finger overlapping the third, abnormal palmar creases and ulnar deviation of the third, fourth and fifth fingers, partial syndactyly of the second and third toes bilaterally, the first toe shorter than the second and a harsh cardiac murmur.

Respirations were rapid and shallow. The heart rate was 180 to 200 per minute. The liver was palpable 4.0 cm. below the right costal margin. An electrocardiogram showed marked right axis deviation. No abnormalities were detected in hematologic surveys or in blood chemistries.

Roentgen skeletal surveys revealed the following: Chest. The heart was enlarged. The ribs were thin. The anteroposterior diameter of the chest was increased and the sternum was short (Fig. 6). Hands. The fingers were held in marked flexion. When forcibly straightened, the third, fourth and fifth fingers deviated to the ulnar side (Fig. 3, A and B). Feet. The big toes were shorter than the second toes. Most of the phalanges were unossified. Some increased spacing was noted between the first and second toes. Trunk. There was a hemivertebra at D<sub>12</sub>. The pelvis appeared small relative to the thorax. Skull. The mandible was small and receded.

During the patient's  $5\frac{1}{2}$  months of life, he gained only 740 gm. and developed poorly. He was unable to hold his head erect, smile or roll over. He blinked his eyes when challenged with a strong light but did not follow objects or respond to auditory stimuli. The infant was placed on a regimen of oxygen, digoxin and antibiotics but eventually failed to respond. At autopsy, among other anomalies, tetralogy of Fallot, muscular defects in the diaphragm, incomplete rotation of the mesentery, a single "double" kidney on the left side with four arteries and asymmetry of the cerebral hemispheres and cerebellum were found.

Chromosomal analysis was performed by a modification of the Hungerford method from peripheral blood mononuclear cell cultures. Each cell examined had 47 chromosomes. It could not be determined whether chromosome 17 or 18 was present in triplicate (Fig. 1).

Case III. A white male was admitted to The Mount Sinai Hospital at 23 days of age for evaluation of a cardiac murmur. The infant was born of a 27 year old mother and a 29 year old father. Gestation was 40 weeks and the birth weight was 6 pounds, 5 ounces. At the time of delivery a large omphalocele was found and corrective surgery was performed 2 hours later. At the time of surgery, the infant had several

cyanotic episodes. Cyanotic periods were noted again at 3 days of age.

On admission to The Mount Sinai Hospital the child was cyanotic and in acute respiratory distress. Clinically, the patient manifested evidences of a congenital cardiac defect, congestive heart failure and pneumonitis. A chromosomal abnormality was suggested by a complex of anomalies: low set malformed ears, receding chin, small triangular mouth, high arched palate, shield-like chest, and flexion deformities of the fingers. Chromosomal analysis was performed on mononuclear cell cultures from the peripheral blood. Each of the examined cells had 47 chromosomes with 5 chromosomes in the group 17-18. It could not be determined with certainty which of the 2 chromosomes was present in triplicate. The child was treated with antibiotics, digoxin and oxygen and gradually improved. Hemoglobin, however, fell to 6.1 gm. per cent and the patient died suddenly 75 days after birth.

At autopsy, numerous anomalies were found: ventricular septal defect, patent ductus arteriosus, malformed cardiac valves, a Meckel's diverticulum, a short mesenteric root and numerous small cysts of both kidneys. No source of bleeding was elicited.

#### ROENTGEN FEATURES

At this writing, 17 cases of the trisomy 17–18 syndrome have been reported. The frequency with which such reports are forthcoming would indicate that this syndrome will probably be found to be of relatively common occurrence. The anomalies which have been described in this condition vary in degree and some of them are not present in all cases. The large number of anomalies which has been present in practically all reported cases, however, is striking.

The roentgenographically demonstrable anomalies which are most constant in this syndrome are as follows:

I. Abnormalities of the fingers. The fingers are held in flexion with frequent overlapping of the second finger on the third. This can often be appreciated on roentgenograms when there has been no attempt to straighten out the fingers. When the fingers are straightened, the second, third and fourth digits are deviated to the

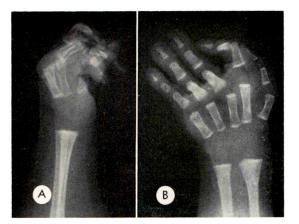


Fig. 3. Case II at 13 weeks of age. (A) Lateral view of the right hand with the fingers in their natural position shows persistent flexion of all fingers excepting the thumb. (B) Anteroposterior view of the right hand with an effort to straighten the fingers shows ulnar deviation of the third, fourth and fifth digits and persistent flexion of the second. The first metacarpal appears short.

ulnar side creating a wide V between the second and third fingers (Fig. 2; and 3B).

- 2. Abnormalities of the toes. The big toe is dorsiflexed and shorter than the second toe (Fig. 4 A). Soft tissue syndactyly between the second and third toes is a common finding (Fig. 4 B).
- 3. Micrognathia. Along with malformed low set ears, micrognathia is the most constant anomaly of the syndrome. It has been present in every case described to date. It is quite obvious on roentgenograms made of the skull in the lateral projection but varies in degree (Fig. 5).
- 4. Abnormalities of the thorax. In most cases the sternum is short apparently due to defective ossification. In one of the cases mentioned above, at necropsy the xyphoid was absent. The anteroposterior diameter of the chest is usually increased (Fig. 6). Another feature which has impressed us but which has not been mentioned in most reports is the caliber of the ribs. These appear unusually thin (Fig. 7). This is particularly impressive when seen in full term infants.
- 5. Malformation of the heart. In the large majority of cases the chest roentgeno-

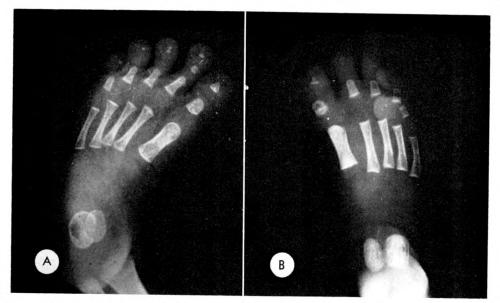


Fig. 4. Case I at I3 weeks of age. (A) Anteroposterior view of the left foot shows a varus deformity of the forefoot. The ossification centers for the middle phalanges of the third, fourth and fifth toes are absent. The big toe is shorter than the second toe. (B) Case II at  $2\frac{1}{2}$  weeks of age. Anteroposterior view of left foot. There is a large V-shaped space between the first and second toes. The cleft between the second and third toes is shallow. The big toe is short and blunt. Most of the ossification centers of the phalanges are absent.

gram has shown an enlarged heart with increased pulmonary vascular markings (Fig. 7). Cardiac malformations regularly include interventricular septal defect and patent ductus arteriosus. Additional car-



Fig. 5. Case I at 15 weeks of age. Lateral view of the skull shows a relatively long posterior foss.. The maxilla extends beyond the hypoplastic mandible. The linear density across the top of the skull is an artifact due to a nasogastric feeding tube.

diac anomalies, however, are often found.

6. Abnormalities of the feet. These may include a variety of anomalies but the most constant features are equinovarus deformity and rocker-bottom feet (Fig. 4 A).

7. Retardation of growth and maturation. Retarded development of several phalanges, the first metacarpals and the big toes is common (Fig. 2; 3, A and B; and 4, A and B). Ossification centers of the cuboid, talus and calcaneus may be retarded. The distal femoral and proximal tibial ossification centers may be absent in full term infants. More commonly, however, there is a small femoral center which tends to remain small during the postnatal months of life if the infant survives for any length of time (Fig. 8). The pelvis tends to be small in most cases. This appears to be partly due to increased forward rotation of the wings of the ilia (Fig. 8).

There are several additional features which may be noted in the roentgen examination of infants with this syndrome. Although not constant, their high incidence

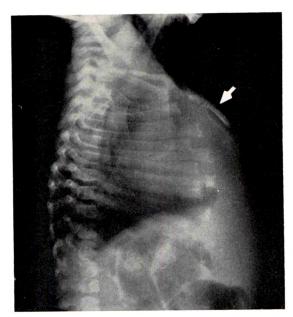


Fig. 6. Case II at 6 months of age. The sternum is short. The anteroposterior diameters of the heart and thorax are increased.

warrants their inclusion among the variable features of the entity. These include: (1) eventration of the diaphragm; (2) malformations of the kidney; and (3) abnormalities in the shape of the skull, frequently with a relatively long posterior fossa and prominent occiput (Fig. 5).

#### DISCUSSION

Low-set malformed ears and hypoplastic mandibles with recession of the chin have been found in all reported cases of this syndrome. These anomalies strongly suggest an early arrest of development. In the embryo the anlagen for the external ears lie below the region that will develop into the mandible. Their normal migration laterally and upward may be arrested at any stage. Incomplete migration of the ears is always associated with hypoplasia of the mandibles and often with hypoplasia of the buccal cavity. It is not known whether hypoplasia of the mandible prevents normal migration of the ears or whether failure of migration inhibits development of the mandible.11 Other anomalies such as ventricular septal defect, patent ductus arteriosus and periumbilical hernia may also reflect developmental arrest. In a high percentage of autopsied cases, a Meckel's diverticulum has been found. Ectopic pancreatic tissue and malformations of the urinary tract have also been noted.

The abnormalities of the hands are of an unusual nature and are of particular diagnostic significance. Persistent flexion of the fingers with the index finger overlapping the third is readily observed clinically but may also often be appreciated on roentgenograms which intentionally or only incidentally include the hands. When the fingers are straightened, ulnar deviation of the third, fourth and fifth fingers can be demonstrated and its possible significance should be noted. Not infrequently, one of the joints of the fingers or toes will show increased resistence to straightening and can be extended only with considerable difficulty. A generalized moderate hypertonia has been a regular finding.

Although at present our experience with cases proven by chromosomal studies is limited, we have been impressed by the thinness of the ribs in these cases and in

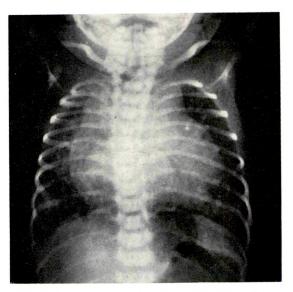


Fig. 7. Case I at 3 weeks of age. The heart is enlarged to the right and left. The pulmonary vascular markings are increased. The ribs are unusually thin. There is a minimal scoliosis of the dorsal spine.



Fig. 8. Case I at 13 weeks. The distal femoral ossification centers are minute. The proximal tibial centers are absent. The transverse diameter of the pelvis above the acetabulum appears small. This is partly due to an increased forward rotation of the ilia. The child is obviously small for her chronologic age.

several others showing the clinical features of the syndrome but who died before specimens for chromosomal analysis could be obtained. Extremely thin ribs may be seen in normal premature infants but they are striking when seen in full term infants with this syndrome. An added factor is that this reduced caliber of the ribs is usually seen in association with a broad chest, an enlarged heart and increased pulmonary vascular markings. In each instance in which we have called attention to this finding on the roentgenograms, clinical stigmata of the syndrome have been found. Some reports, however, do not mention this feature and its diagnostic value must await further observations. It is probably a manifestation of the over-all developmental retardation.

Occasional cases may be seen in which

only a part of the component anomalies of the full trisomy 17-18 syndrome is present. Smith et al.14 have suggested that this may be the result of a partial trisomy. In such an instance, only a part of a chromosome may be present in triplicate, the extra piece being attached to another chromosome. Recently three newborn infants with esophageal atresia and tracheoesophageal fistula have been seen at The Mount Sinai Hospital, all showing several anomalies consistent with the trisomy 17-18 syn drome. Unfortunately, in none of these were chromosomal analyses obtained. Tracheoesophageal fistulae have not been described in any reported case of this syndrome. Whether esophageal atresia will eventually prove to be a common finding in this entity or, possibly, a component anomaly of another as yet undescribed chromosomal aberration will become apparent with future observations in this rapidly expanding field of investigation.

The fact that many of the anomalies resulting from chromosomal aberrations can be demonstrated by roentgenography, and some *only* by roentgenography, warrants the keen interest of radiologists in the exciting new developments in cytogenetics. Continued observation and description of these anomalies can play an important part in the development of criteria for the eventual classification of various syndromes.

#### SUMMARY

- 1. To date, 17 patients have been reported in which trisomy for either chromosome 17 or 18 has been found. The frequency with which certain developmental anomalies are observed in this condition leaves little doubt that this numeric chromosomal aberration results in a clinically recognizable syndrome.
- 2. The complex of anomalies which may be demonstrated by roentgenography permits a roentgen diagnosis of the syndrome in many cases. Characteristic roentgen features demonstrated in 3 cases seen at The Mount Sinai Hospital have been illustrated and discussed.

3. The importance of radiology in the development of criteria for classification of syndromes resulting from chromosomal abnormalities is noted.

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#### DIASTROPHIC DWARFISM\*

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RECENTLY we have encountered an unusual, widespread disorder of mesodermal structures which superficially resembles achondroplasia or, more specifically, a variant of Morquio's osteochondrodystrophy. This condition is characterized by dwarfism and is probably transmitted as an autosomal recessive. It appears to be a basic mesenchymal defect producing abnormalities in bone, cartilage, connective tissue and muscle. We feel that the clinical picture, even at birth, is characteristic and permits relatively easy differentiation from other chondrodysplasias. The roentgenographic appearance in itself presents many unique features. Lamy and Maroteaux<sup>3</sup> recently have recognized this disorder as a separate entity and have reported 3 cases along with a discussion of II others which they were able to find in the literature masquerading under various titles. They applied the term diastrophic from the Greek diastrophos meaning tortuous or twisted. The typical syndrome consists of: (1) dwarfism, (2) infantile structural scoliosis, (3) resistant club feet, (4) characteristic toe and finger deformities, (5) both lax and rigid joints, (6) bilateral hip dysplasia, (7) thickened irregularly shaped external ears, (8) cleft palate, and (9) autosomal recessive transmission. Abnormalities of the skin, hair, nails or teeth have not been noted. There has been no evidence of mental deficiency.

Three children manifesting this syndrome have been seen and examined at The University of Michigan Medical Center. One of the patients, now 5 years of age, has been followed and treated since early infancy, and will be reported in detail.

#### REPORT OF CASES

Case 1. The patient, a white female infant 2 months of age, was referred to The University

of Michigan Medical Center for evaluation and treatment of club feet, dislocated hips, deformed fingers and suspected achondroplasia (Fig. 1).

The patient was born at term on July 1, 1957, following an uncomplicated pregnancy and breech delivery. The birth weight was 6 pounds, 10 ounces. The father, 27 years old, and the mother, 26 years old, were unrelated. A cousin of the patient was born with a deformed finger but the family history revealed no other congenital anomalies.

On examination the child appeared alert, well nourished and healthy. The extremities were abnormally short in relation to the trunk. The head appeared normal except for the ears which were thickened and malformed. Abduction of the hips was limited bilaterally and telescoping was present. The knees were hyperextensible and the feet were in extreme equinovarus. Additional varus deviation of the toes, especially the great toe, was noted bilaterally. Passive motion at the elbows and shoulders was slightly limited. The fingers were short and contracted in extension at the interphalangeal joints. Increased webbing was present. Metacarpophalangeal motion of the fingers was normal. The thumbs pointed out from the palms and were markedly hypermobile at the carpometacarpal and metacarpophalangeal joints.

Roentgenograms from another hospital taken at 2 days of age were reviewed. The distal femoral epiphyses were absent and the proximal tibial epiphyses were small, flattened and apparently displaced medially. The hips and possibly the elbows were thought to be dislocated. There was no significant abnormality of the skull or lumbar spine. The University of Michigan Medical Center roentgenograms obtained at 9 weeks of age showed little change. The findings were thought to represent some form of atypical chondrodysplasia.

Observers in the Orthopaedic Department felt that the child presented features of both achondroplasia and arthrogryposis. The hip dysplasia was thought more specifically to represent coxa vara bilaterally rather than true dislocation, and treatment was deferred. A pro-

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gram of progressive cast correction of the club feet was begun while in the hospital and continued in the out-patient department.

The patient was readmitted to The University of Michigan Medical Center in April, 1958, for further roentgenographic examination of the hips. Bilateral dislocations were demonstrated (Fig. 2). Closed reduction was unsuccessfully attempted and in May, 1958, an arthrotomy of the right hip was performed. The femoral head was quite enlarged, flattened and deformed. It was resting in a false acetabulum and reduction was not possible.

The attempted cast correction of the club feet proved totally unsuccessful and in January, 1960, bilateral medial soft tissue releases were performed followed in 1 month by posterior capsulotomies, posterior tibial and Achilles' tendon lengthenings bilaterally. Kirschner wires inserted through the os calcis along with Kirschner wire bales were incorporated in long leg plaster casts. The wounds healed *per primum* but, gradually and progressively, the club foot deformities recurred. The patient was readmitted in April, 1961, for thorough evaluation and additional surgery for the recurrent club feet.

Examination of the patient, now aged 3 years and 9 months, revealed a moderately obese, happy, alert white female. The head was grossly normal. Abnormalities of the external ears were again noted (Fig. 3). The child measured 32 inches from crown to heel with an arm span of 26 inches. There was mild limitation of shoulder abduction and elbow extension. The wrist motion was normal. The hands presented a number

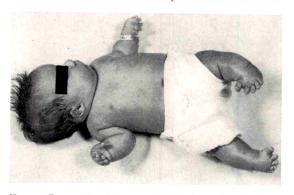


Fig. 1. Case 1. Aged 2 months. The head is relatively normal except for the thick, irregular external ears. The extremities are abnormally short. The fingers are contracted in extension at the interphalangeal joints. The thumb is hypermobile. The feet are in rigid equinovarus with additional varus of the toes.



Fig. 2. Case I. Aged 7 months. Roentgenogram of the pelvis including both hips and knees shows symmetric dislocation of hips. Ossification centers have not yet appeared. Flattened epiphyses at the knees are distinctive as is the normal appearance of the bony pelvis.

of interesting features (Fig. 4, A and B). The palm appeared long in comparison to the short stubby fingers. Webbing was markedly accentuated. Extension contractures of the interphalangeal joints were again noted, essentially un-

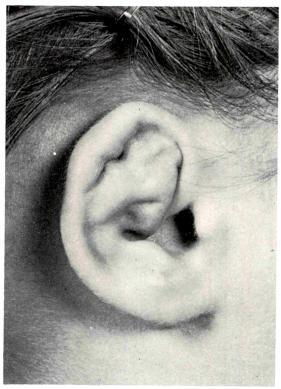


Fig. 3. Case I. Aged 3 years, 9 months. The normal landmarks of the external ear are distorted. The cartilage is thickened and irregular.

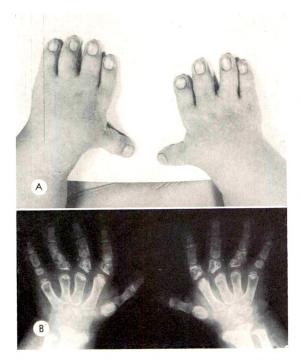


Fig. 4. Case I. Aged 3 years, 9 months. (A) The fingers are contracted in extension at the interphalangeal joints. The thumbs may be easily abducted an additional 90 degrees without discomfort. Extensive soft tissue webbing is present. (B) All metacarpals and phalanges are relatively short, but underdevelopment of each first metacarpal is especially striking. The significance of the bizarre ossification pattern of the proximal phalanges and the dish-like deformity of the distal radial epiphyses is indeterminate. Note multiple carpal ossification centers.



Fig. 5. Case i. Aged 2½ years. Pronounced shortening of each first metatarsal and tortuosity of the others exaggerate the talipes equinovarus. The distal tibial epiphyses are flat.

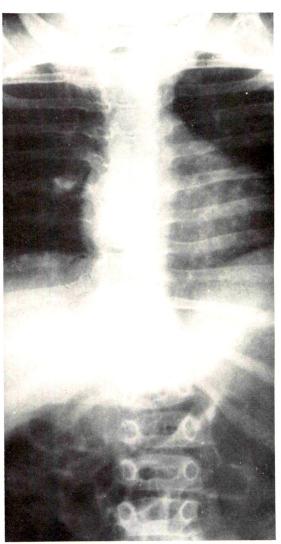


Fig. 6. Case I. Aged 3 years, 9 months. Anteroposterior roentgenogram of the spine showing moderate but definite structural scoliosis.

changed from birth. The hypermobility of the thumbs had also persisted. The child used the fingers actively and dextrously. In the lower extremities, the hips presented 30 degree flexion contractures with limitation of motion in all directions. The knees, in contrast, were hypermobile, permitting full flexion and 20 degrees of hyperextension along with laxity of both collateral and both cruciate ligaments. The feet were again in fixed equinovarus (Fig. 5). The back presented a moderate but uncorrectable scoliosis that was not present at birth (Fig. 6). Complete examination of the eyes showed the following pertinent findings: the eyes were

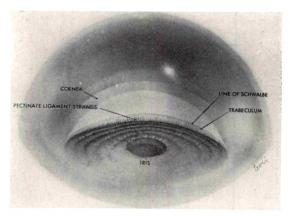


Fig. 7. Artist's drawing of the chamber angle showing thick pectinate ligament strands indicative of systemic connective tissue disorder.

straight, the visual acuity, extra-ocular motility and tension were normal. The ophthalmoscopic examination was normal. Gonioscopic examination, however, revealed rather striking changes (Fig. 7). Both angles were open but numerous, thick pectinate ligament strands could be seen arising from the root of the iris throughout its circumference (vide infra). Neurologic examination was grossly normal. Psychometric examination showed no evidence of mental deficiency.

Hemoglobin, white blood cell count, urinalysis, serology, calcium, phosphorus and phosphatase determinations were repeatedly normal. Quantitative measurements of acid mucopolysaccharides in the urine were normal. Urine creatinine was 260 mg. and 290 mg. while creatine was 348 mg. and 272 mg. on separate 24 hour urine measurements. Serum protein electrophoresis revealed the following pattern: albumin, 43 per cent, alpha I globulin, 6 per



Fig. 8. Case II. Aged 9 months. The head and face are normal in appearance except for external ears which are irregularly formed. The extremities are short in relation to the trunk. The fingers are contracted in extension. The thumbs are hypermobile. Hip motion is limited. The knees are hypermobile and the feet are in rigid equinovarus.



Fig. 9. Case II. Aged 9 months. Bilateral hip joint dislocation, absence of capital femoral ossification centers and flaring of upper femurs. There is typical flattening of the epiphyses at the knees and disproportionate shortening of the fibulas.

cent, alpha 2 globulin, 13 per cent, beta globulin, 15 per cent and gamma globulin, 23 per cent. Serum glutamic oxalacetic transaminase was 80 units and 73 units and serum aldolase was 10.1 units and 4.8 units, respectively.

The electromyogram detected denervation fibrillations and complex motor units in sampled areas including the right deltoid, right anterior tibial, right extensor digitorum longus and left gastrocnemius and soleus muscles. A biopsy of the left flexor digitorum longus muscle revealed areas of patchy atrophy and fatty infiltration.

Because of the recurrence of club foot deformities, medial soft tissue releases, posterior capsulotomies and Achilles' lengthenings were again performed. Long leg walking casts were applied and crutch walking was begun.

Case II. The patient, a female sibling of Case I, was born on July 12, 1960, following an uncomplicated pregnancy and delivery, the





Fig. 10. Case II. Aged 9 months. (A) Short, almost triangular, first metacarpal and irregular ossification of proximal and middle phalanges of left hand. Right hand identical in appearance. Compare with Figure 4B. (B) Anteroposterior roentgenogram of the feet shows underdevelopment of first metatarsals along with marked equinovarus deformity.

mother's third. The second child is normal. Multiple deformities were recognized at birth and cast correction of the club feet was begun on the second day. She was seen and examined at The University of Michigan Medical Center in April, 1961, at the age of 9 months. Examination at that time revealed an alert, white female with deformities almost identical to those of her older sister (Fig. 8). No abnormalities of the heart, lungs, abdomen, skin, teeth, hair or nails were detected. The palate was intact. The appearance of the head and face was normal except for the external ears which were irregularly thickened with loss of normal landmarks. Abduction of the shoulders was limited at 80 degrees. The elbows lacked 20 degrees of full extension. Wrist motion was normal. The fingers were contracted in extension at the interphalangeal joints. Metacarpophalangeal joint motion was normal. The thumbs were hypermobile at the carpometacarpal and metacarpophalangeal joints. Examination of the trunk

revealed no evidence of scoliosis. The hips seemed located but motion was limited in all directions while the knees showed considerable ligamentous laxity permitting subluxation of the tibias on the femurs. The feet were in rigid equinovarus with additional varus of the toes.

Roentgenographic examination at the age of 9 months showed various skeletal structures to be virtually identical in appearance to those of the patient's sister (Case 1). There was shortening of all tubular bones with flattening of the epiphyseal ossification centers at the knees. The fibulas were considerably shorter than the tibias and each proximal tibial epiphysis seemed to be displaced medially. Bilateral club feet and dislocation of the hips were evident. Neither the capital femoral or humeral epiphyses had appeared and the trochanteric portion of each femur had a rather distinctive flared configuration (Fig. 9). Underdevelopment of each first metacarpal and metatarsal was again a most striking finding as was irregular ossification of

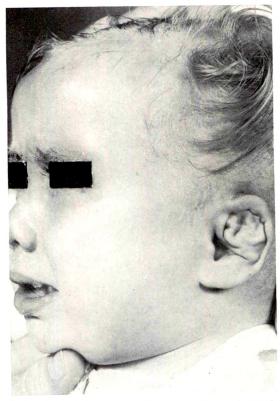


Fig. 11. Case III. Head size and shape are grossly normal although mild frontal bossing and flattening of the nose are present. Note typical corrugated irregularity of the external ears.

the proximal and middle phalanges of the hands (Fig. 10, A and B). Mild scoliosis was evident but otherwise the spine as well as the skull and pelvis appeared normal. The final roentgenographic diagnosis was "bizarre chondrodysplastic dwarfism of indeterminate type."

CASE III. The patient, a white female, was born on July 25, 1959, following a term pregnancy and uncomplicated delivery. The mother had been pregnant II times. Two pregnancies ended in abortion at approximately 4 months. The second child, a male, and the third, a female, died at 2 days of life and 3 days of life, respectively. Both were reported to have had short extremities, deformities of the hands and club feet. The mother had had 6 other children who are perfectly normal in all respects. No other congenital anomalies have been reported in the family. The mother consulted The University of Michigan Medical Center Heredity Clinic regarding the probability of similar deformities being perpetuated in the family. The patient along with her parents and siblings was examined at The University of Michigan Medical Center in June, 1961.

The patient was an alert, well nourished white female, aged I year and II months. Gross shortening of the extremities was present with the humerus and femur being disproportionately shorter. Mild frontal bossing and flattening of the nasal bridge was noted. Head size and shape otherwise appeared normal. An intraoral examination revealed a cleft palate. The external ears were malformed (Fig. 11). The cartilage was thickened and irregular and the normal configuration was distorted. There was slight limitation of shoulder motion. Elbow motion was normal. Both wrists were held in ulnar deviation and could be passively corrected only to neutral. The fingers were short and contracted in extension at the interphalangeal joints. The thumbs were hypermobile and permitted wide abduction. The child used the fingers actively but preferred to hold objects between the third and fourth fingers. Examination of the trunk revealed a moderate scoliosis. The lower extremities presented mild flexion contractures at the hips. Abduction was limited bilaterally and telescoping was possible on the right. Bilateral flexion contractures were present in the knees with motion present from approximately 45 to 165 degrees bilaterally. The right foot was contracted in a rigid equinovarus



Fig. 12. Case III. Shortening of all tubular bones of right arm and hand with marked underdevelopment of first metacarpal producing typical deformity of thumb. Accelerated carpal ossification of doubtful significance. The left arm is identical in appearance.

position. The left foot was less contracted posteriorly although metatarsus varus was present. There was additional medial deviation of the toes.

The right Achilles' tendon had been lengthened at 15 months of age and repair of the cleft palate is planned.

Roentgenographic examination of skeletal structures in early infancy was carried out at another hospital and a diagnosis of achondroplasia was made. No scoliosis was present although there was a peculiar kyphosis of the cervical spine.

Re-examination at University Hospital showed generalized shortening and broadening of all the long tubular bones. There was considerable lateral bowing of each radius and disproportionate shortening of each ulna, but the most striking abnormality was marked underdevelopment of each first metacarpal (Fig. 12). Bilateral dislocation of the hips and talipes equinovarus deformities were noted. Although the ossification center for the greater tubercle of each humerus was well formed, the centers for the capital humeral and femoral epiphyses were totally absent. Epiphyseal ossification centers at the knees were irregular and flattened and the central portion of each distal femoral metaphysis displayed an unusual central depression into which the adjacent epiphysis had adapted itself (Fig. 13). Moderate dorsal scoliosis was evident. The skull and pelvis appeared normal. By this time the article of Lamy and Maro-



Fig. 13. Case III. Roentgenogram of the knees. Flattened, deformed distal femoral and proximal tibial epiphyses. Peculiar central indentation of femoral metaphyses. Medial displacement of tibias and fibulas in relation to femurs.

teaux<sup>3</sup> had come to our attention, and a diagnosis of diastrophic dwarfism was made.

#### GENETICS

Our families, as well as those in the literature support the notion that diastrophic dwarfism arises as a consequence of homozygosity for a rare, autosomal gene. One observes that the parents and more remote ancestors of affected individuals are normal, both sexes are affected and equally often; and the distribution within sibships of affected individuals is consistent with the segregation ratio expected of a single, completely recessive, rare, autosomal gene. It is disturbing, however, that as yet no affected individual is known who was born to related parents. Uncommon as this defect appears to be, one would expect, on theoretic grounds, a conspicuous increase in consanguineous marriages. An alternative, but, perhaps less probable genetic hypothesis which could account for the inexplicable absence of consanguineous marriages, is one which attributes the defect to simultaneous heterozygosity for two rare, autosomal genes.

#### ROENTGENOLOGIC ASPECTS

The distinctive combination of clinical and roentgenologic signs makes diastrophic dwarfism clearly recognizable at any age. It is our opinion that in infancy and early childhood, the diagnosis can be made on the basis of roentgen findings alone. The flattened, medially placed epiphyseal ossification centers at the knees, the striking, seemingly inevitable maldevelopment of each first metacarpal, the characteristic trochanteric broadening of the femurs and selective delay in the appearance of the ossification centers for the capital femoral and humeral epiphyses constitute a constellation of roentgenographic signs that is, at least, highly suggestive. Add to this the roentgen signs of club feet, dislocated hips and scoliosis, and the diagnosis is confirmed. The less constant findings of disproportionate shortening of the ulna and fibula, bowing of the radius, irregular ossification of the phalanges and variations in the appearance of carpal ossification centers may or may not prove to be significant as additional cases are observed. Lamy and Maroteaux<sup>3</sup> have called attention to the peculiar change in the shape of the distal femoral epiphyses and metaphyses which is especially pronounced in late childhood. This deformity, which may be nonspecific, is also illustrated by our Case III, at the age of 23 months (Fig. 13).

#### DIFFERENTIAL DIAGNOSIS AND DISCUSSION

A number of eponyms and descriptive terms has been applied to the wide variety of conditions characterized by abnormal musculoskeletal growth and development. Frequently, there is no clear cut dividing line and the terminology often serves more to confuse than clarify. This overlapping has been stressed by Jackson<sup>2</sup> in his plea for a simplified classification. He feels, and not without merit, that attempts to separate out more and more of these as distinct diseases is not scientifically justifiable. On the other hand, there is often marked clinical and prognostic value in such separations. Furthermore, advances in biochemistry and enzymology may soon permit more accurate division in the areas of overlapping. This point is well illustrated by the determination of abnormal urinary excretion of chondroitin sulfate 13 and heparitin sulfate in gargoylism.<sup>5</sup>

In regard to diastrophic dwarfism, we must agree with Lamy and Maroteaux³ that the over-all picture appears unique and the major characteristics are surprisingly constant. We may attribute lack of earlier recognition to its rare occurrence. It was not until we had seen 2 cases of our own and had an opportunity to review the article of Lamy and Maroteaux³ that we recognized the features as distinctive.

Diastrophic dwarfism may be distinguished from achondroplasia, Morquio's osteochondrodystrophy, Hurler's drome, multiple epiphyseal dysplasia and spondyloepiphyseal dysplasia rather readily. Lamy and Maroteaux<sup>3</sup> state that this condition simulates achondroplasia very closely for the first 3 years but follows a different evolution. We believe the distinction may be made clinically as well as roentgenologically at birth or shortly thereafter. The combination of scoliosis, club feet, contracted interphalangeal joints of the fingers, ear deformities and cleft palate, so typical in diastrophic dwarfism, is characteristic of none of the above conditions. The presence of multiple joint contractures at birth reminded both Lamy and Moroteaux and us of arthrogryposis, although we are aware of no report linking arthrogryposis with any of the chondrodystrophies.

With regard to dwarfism, shortening is usually quite severe. It is due in part to the kyphoscoliosis and the frequent development of knee and hip flexion contractures. However, definite shortening of the limbs is noted as well, occurring primarily in the humerus and femur. The reported cases in adults have all been well under 5 feet. Jackson's patients measured 4'6", 4'1" and 4'1" in height, respectively; those of Lamy and Maroteaux were even more dwarfed at 3'11" and 3'6", respectively.

The scoliosis is of special interest and appears to be almost a constant finding. Although not present at birth, it develops

early and cannot be attributed to anomalous vertebrae. Eventually structural features can be identified and passive correction is impossible. In adults, the kyphoscoliotic deformity is usually severe.

Talipes equinovarus has been present in 16 of 17 reported cases. Many have proven quite resistant to treatment. Our Case I has required 3 separate surgical procedures on each foot and continues to show a tendency to recur. A dynamic muscle imbalance, probably secondary to a basic mesenchymal defect, would seem to be largely responsible. The elevated serum glutamic oxalacetic transaminase may indicate a muscle abnormality. This concept is further supported by electromyographic findings of complex motor units and denervation fibrillations, although the latter may well point to a neurogenic component.

Interesting findings in the hands including interphalangeal joint contractures, abducted, hypermobile thumbs and increased webbing have been described by Meisgeier<sup>4</sup> as well as by Lamy and Maroteaux<sup>3</sup> and are demonstrated by all 3 of our cases.

Regarding the hips, specific description has not always been made but in those that we can determine, coxa vara, frank dislocation or both have been present.

Anomalies of the ear and palate have been less constant features. Cleft palate has been reported in 4 and ear deformities in 10 of the 17 cases. Eye changes similar to those seen in our Case 1 have been studied by Burian *et al.*, and although nonspecific and of no significance with respect to the function of the eye, appear to be definitely associated with systemic connective tissue disorders.

The prognosis for life, at least in those who survive early infancy, appears to be good. Jackson's<sup>2</sup> 3 cases were siblings, 2 females aged 62 years and 52 years and a male aged 56 years. All 3 had enjoyed good general health although the deformities had been essentially untreated. Severe club feet were present in all 3; 2 had marked kyphoscoliosis of the spine and 2 required

crutches. Case III of Lamy and Maroteaux<sup>3</sup> had required multiple surgical procedures.

#### SUMMARY

Three cases of diastrophic dwarfism are presented and the distinctive features are discussed. Particular emphasis is placed upon the characteristic clinical and roent-genologic signs which are recognizable in infancy.

The typical clinical features are: dwarfism, scoliosis, club feet, hip dysplasia, ear deformity, contracted interphalangeal joints and hypermobile thumbs. The unique roentgenologic picture consists of flattened offset epiphyseal ossification centers at the knees, trochanteric broadening of the femurs, shortening of the long bones, maldevelopment of the first metacarpal and irregular ossification of the phalanges. The appearance of the skull and pelvis is normal.

Diastrophic dwarfism appears primarily to involve mesodermal structures in a widespread manner. Autosomal recessive transmission characterizes the hereditary pattern.

Prognosis for life is good although the

multiple deformities are frequently severe and difficult to treat.

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## THE UNUSUAL OCCURRENCE OF SCURVY IN AN EIGHT WEEK OLD INFANT\*

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In THIS day of fortified foods, formulas, supplemental vitamins, and well-baby clinics, scurvy in infants has become a rarity. Infants are born with adequate stores of vitamin C when the mother's vitamin C intake has been sufficient. However, since ascorbic acid is not synthesized in man, there is complete dependence on either diet or dietary supplementation.

Nelson<sup>10</sup> states that scurvy may occur at any age, although it is extremely rare in the newborn infant, but Caffey<sup>2</sup> feels that there are no authentic cases of symptomatic or roentgenographic scurvy in infants younger than 3 months. Caffey believes that those cases reported as representing scurvy in the very young infant probably represent misinterpreted roentgen changes of skeletal syphilis.

A survey of the literature reveals that several cases of "congenital scurvy" have been reported. For example, Liu reported a case in 1931, in which the diagnosis was based upon clinical signs which developed on the seventh day after delivery, but roentgenograms made on the seventeenth day revealed no abnormalities.6 Hill reported a similar case in 1932, that of an infant 3 weeks of age who was said to have had painful, swollen limbs, roentgenographic findings typical of scurvy, and a good response to orange juice therapy.6 Jackson and Park<sup>6</sup> reviewed this case and suggested that a definite opinion was impossible because of the poor quality of the reproduced roentgenograms and believed that the probable diagnosis was congenital syphilis. Tupas reported 2 cases occurring in infants under 2 months of age whose roentgenograms were said to have shown changes diagnostic of scurvy, but unfortunately no roentgenograms were reproduced in this article and no serological tests were reported.<sup>6</sup>

It would seem that the major factor offered as diagnostic proof in these cases was the response to vitamin C therapy. To some authors this is considered proof enough. Brailsford<sup>1</sup> states that the best proof of scurvy may be the response to the therapeutic test—complete resolution of the lesion when adequate vitamin C is administered.

Jackson and Park<sup>6</sup> did present an apparently indisputable case of "congenital scurvy" complete in all its clinical, roentgenographic and pathologic aspects. The diagnosis was made in retrospect following postmortem examination. It was found that the mother of the infant, who herself had clinically active scurvy, had breast-fed the child without supplementation. On admission, at 16 days of age, the appearance of the infant was that of generalized malnutrition. The infant died within a few days and autopsy revealed subarachnoid and intracerebral hemorrhage, together with hemorrhage along epiphyseal plates. Roentgenograms of the skeleton, obtained at postmortem examination after removal of soft tissues, showed abnormalities which resembled scurvy. Serological tests of both mother and infant revealed no evidence of syphilis.

Ingalls<sup>5</sup> reported 2 cases of scurvy occurring in premature infants in whom fully developed bony changes were found, although no clinical signs were present. One infant died at 26 days of age and the other at 32 days without any noticable response to vitamin C therapy.

Thus it would appear that there are

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indeed very few, if any, authenticated cases of scurvy occurring in infants under the age of 3 months. The case described below, however, is thought to represent true scurvy in an 8 week old child who had both clinical and roentgenographic evidence of this disease.

#### REPORT OF A CASE

The patient was an 8 week old, white female, who was admitted to Parkland Memorial Hospital upon referral by her family physician because of "bad skin color, irritability, and failure to thrive." The infant had been the product of an uncomplicated 9 months' gestation and a normal delivery, and had weighed 7 pounds, 2 ounces at birth. During pregnancy, the mother had taken vitamins regularly and her diet was good. From birth, the baby had been fed a daily formula of 5 ounces of Pet milk, 10 ounces of water, and 1½ tablespoons of Karo syrup. The

baby had taken the formula in adequate amounts but solids, when offered, were refused. No citrus juices or vitamins had been administered. During the 4 weeks immediately prior to admission, the patient was said to have had three illnesses described by the mother as being influenza, measles, and chicken pox.

At 5 weeks of age, the baby had become irritable and cried much of the time, especially with motion of the legs. The mother had also noted that the child had become progressively less active, no longer kicking her legs. At no time could a history of trauma be elicited.

The physical examination on admission revealed a malnourished infant with notably prominent hips and thighs, wrinkled, dusky skin, and puffy eyelids. The infant now weighed 7 pounds, 8 ounces. Chest and abdomen were normal by examination except that the liver was palpable. The legs were flexed and any attempt to manipulate the legs brought on bouts of crying, as if the child suffered pain. Otherwise, she



Fig. 1. (A and B) Roentgenograms at 8 weeks of age showing demineralization, thinning of the cortices, Wimberger's ring, the white line of Frankel, and the proximal radiolucent zone in the long bones.



Fig. 2. Both femurs at 3 months of age, following 3 weeks of vitamin C therapy, show calcification of subperiosteal hemorrhage of the distal right femur, fragmentation in the region of the distal metaphysis of the left femur, and the other signs of scurvy.

did not cry during physical examination. The legs were equal in length, but lacked normal muscular power. There was no evidence of acetabular dysplasia. Neurologic examination was normal except for diminished patellar reflexes bilaterally.

Laboratory tests were as follows: Kolmer test (modification of complement fixation test)<sup>9</sup> anticomplementary; VDRL nonreactive; serum calcium 9.9 mg. per 100 ml.; serum phosphorus 4.7 mg. per 100 ml.; alkaline phosphatase 4.1 Bodansky units; hemoglobin 8.4 gm. per 100 ml.; serum ascorbic acid 0.1 mg. per 100 ml. A buffy coat vitamin C determination was not performed. The serological tests did not show the presence of congenital syphilis. The serum ascorbic acid level was well below the limits of normal by standards of this laboratory (a finding frequently found in scurvy, but not diagnos-

tic because the value depends on amount of recent vitamin C intake).

Certain serological tests were also performed on the mother, including VDRL and Kolmer tests; both were nonreactive.

Roentgen studies were performed during the course of hospitalization. Roentgenograms (Fig. I, A and B) made on the first hospital day, showed evidence of demineralization and cortical thinning, most marked at the ends of the long bones; the white line of Frankel across the distal metaphyses; radiolucent zones proximal to the dense area of calcification; ground-glass appearance and rings of increased density about the distal femoral epiphyses; and evidence of minimal fragmentation in the region of the left distal femoral metaphysis. A study made on the twentieth hospital day (Fig. 2), showed essentially the same findings as before but with more evidence of fragmentation of the distal left femoral metaphysis, and the appearance of subperiosteal calcium deposition about the distal right femur, indicating previous subperiosteal hemorrhage. The patient had been on vitamin C therapy for approximately 3 weeks prior to this examination.

These findings are in accord with most of the classic roentgenographic signs of scurvy: (a) the white line of Frankel across the distal metaphysis; (b) small bony spurs at the lateral extremities of the metaphyses (Pelkan spur); (c) a radiolucent zone proximal to the dense metaphysial line (Trummerfeld zone); (d) rings of increased density about the peripheries of the epiphyses (Wimberger's line); (e) relative radiolucency of all the bones, including the central areas of the epiphyses; (f) marked cortical thinning; (g) subperiosteal hemorrhage with and without calcification, the calcification usually appearing immediately after the institution of therapy; (h) some degree of epiphysial separation or fragmentation in the region of the metaphysis; and (i) the prominence of the costochondral junctions.7,8

During hospitalization, ascorbic acid therapy (250 mg. daily) was instituted and improvement was noted by the sixth hospital day. A low grade fever was present initially, but the infant became afebrile on the fourteenth hospital day. Tuberculin and histoplasmin skin tests were negative. Needle aspiration of the left hip was performed on the fourth hospital day and no fluid was obtained. The patient was discharged

after 29 days of hospitalization with definite improvement in skin color and general physical condition. Leg motion was no longer painful. Again, there was no suggestion of acetabular dysplasia.

The child was returned 2 months later for roentgen study which showed (Fig. 3) more normal mineralization of bony structures, thickened cortices, and absence of the previously noted findings of scurvy. "Growth arrest lines" were present in the femurs. There was dislocation of the left hip and the left femoral capital epiphysis was smaller than the right. While this defect is felt to have its origin in acetabular dysplasia, the destruction of the epiphysis during the acute scorbutic episode with resultant deformity was considered an alternate possibility.

Comment. Several authors have stated that 2 or 3 months of vitamin C deficiency are required for the development of clinical and roentgenographic signs of scurvy.<sup>3,4</sup> The case presented by Jackson and Park<sup>6</sup> proves that congenital scurvy can occur in breast fed infants who are born of scorbutic mothers and who receive no supplemental vitamins. The present case also illustrates that scurvy can occur before 3 months of age—in this instance in an infant debilitated by repeated illnesses and an inadequate diet.

#### SUMMARY

- 1. Scurvy in the United States is rare; however, it may occur in the neglected child.
- 2. Most authorities state that scurvy does not occur in infants under 3 months of age, but a survey of the literature reveals several reported cases, some in which definite proof is lacking and others which seem indisputable.
- 3. A case report is presented of scurvy in a 2 month old female, along with reproductions of roentgenograms which show most of the roentgen signs thought to be typical of the disease.

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Fig. 3. Both femurs at 5 months of age, after 3 months of vitamin C therapy, reveal the absence of the classic roentgen findings of scurvy, bilateral "growth arrest lines," more normal mineralization and thickening of cortices. The left acetabular dysplasia is now evident.

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#### THE SKULL IN SKELETAL DYSPLASIAS\*

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ALTHOUGH the entities forming the group of congenital skeletal dysplasias are described as separate, clear-cut conditions, it is well known by the radiologist that there are many cases where a definite distinction cannot be made. The roentgenologic picture cannot always be classified under a single heading. The number of these "atypical" cases of bone dysplasias has increased lately with increasing knowledge and recognition of these conditions.

A correlation of the bone dysplasias was attempted recently<sup>24</sup> by association of common features present in some of these cases. This correlation is valid but a careful examination of the roentgenographic manifestations occurring in the skull of these patients brings out distinctive features that help differentiate one bone dysplasia from another. The skull findings are thus of valuable assistance for the diagnosis and classification of the congenital bone dysplasias, particularly when the abnormalities found in the skeleton are atypical and cannot be related as forming part of a definite entity.

A review of the skull findings in these dysplasias will help to illustrate their importance. The grouping adopted by Caffey is followed here, but with some modification. These conditions can be organized under three sections: (1) congenital cartilaginous dysplasias, (2) congenital periosteal dysplasias, and (3) miscellaneous dysplasias.

### CONGENITAL CARTILAGINOUS DYSPLASIAS (TABLE I)

#### ACHONDROPLASIA

Constriction of the basal segment of the skull is found in association with dilatation of the cranial vault (Fig. 1). This is due to the formation of the so-called os tribasilare by premature synostosis involving the basi-

occipital and the body of the sphenoid bone (pre- and postsphenoid). The shortening of the base of the skull produces a sunken base of the nose accompanied by frontal bulge and generalized dilatation of the calvarium with occasional eversion of the lips of the anterior fontanel. Premature synostosis can occur at the exoccipital and supra-occipital portions of the occipital bone resulting in narrowing of the foramen magnum which may in turn produce obstructing hydrocephalus.

The maxilla in these cases recedes and makes the jaw appear protruding. Multiple unerupted teeth are found.

#### OSTEOCHONDRODYSTROPHY

In Morquio's disease the skull remains grossly normal in contrast to the changes suffered by the neck and trunk. There have been cases reported where hydrocephaly and delayed eruption of the teeth occurred.<sup>11</sup>

#### CHONDROECTODERMAL DYSPLASIA

The Ellis-Creveld syndrome occurs without changes in the skull aside from those present in the teeth, reported as dental dysplasia. This is found in other dysplasias and cannot be used as a differentiating point. Malocclusion of the teeth is mentioned by Caffey as due to enlargement of the maxilla and underdevelopment of the mandible. Submaxillary calcifications are occasionally present and are of uncertain origin.

#### CHONDROMATOSIS

Cases of multiple familial exostosis (external chondromatosis) show increased digital markings in the frontal area of the calvarium. This may be a normal finding in skulls of children between the ages of 3 and 10 but seems to occur more frequently in

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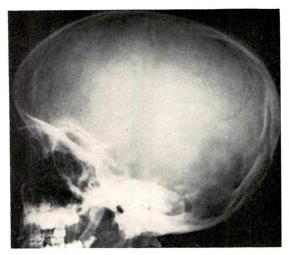


Fig. 1. Skull roentgenogram of an achondroplastic child shows frontal bulging and mild dilatation of the vault. The base is foreshortened.

cases of external chondromatosis. A deep posterior fossa may be found in these skulls.

No skull abnormalities have been reported in cases of Ollier's disease (internal chondromatosis).

#### METAPHYSEAL DYSOSTOSIS (HYPOPHOSPHATASIA)

Skull changes typical of this condition have been described recently.9 A defective ossification of the skull can be detected early in life and the bones appear entirely uncalcified. The failure in bone formation is later manifested by wide sutures and soft tissue bulging of the anterior fontanel; this indicates a discrepancy of rate of growth between the skull bones and their contents. The ossification of the cranial bones proceeds slowly and the suture lines appear irregular and mottled. Premature closure of the sutures occurs later and the skull adopts the shape and pattern found in craniostenosis. Premature shedding of deciduous teeth is a prominent feature and should not be overlooked when examining the skull roentgenograms of patients with hypophosphatasia (Fig. 2).

#### OSTEOPETROSIS

Typical roentgenologic changes are found in the skulls of patients afflicted with this disease. These changes are of the same degree as those present in the entire skele-

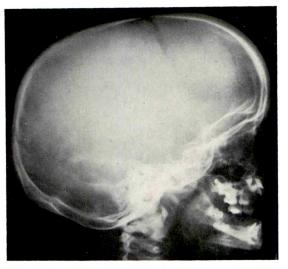


Fig. 2. Two year old child with hypophosphatasia. The coronal suture is slightly widened. Note the premature loss of deciduous teeth.

ton. All the bones of the face and skull appear structureless, thickened and markedly sclerotic. The bones of the calvarium appear stony hard and brittle; the differ-

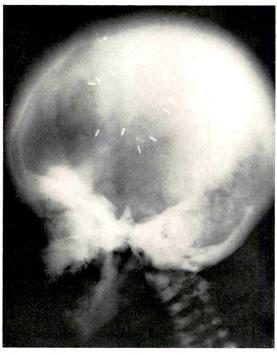


Fig. 3. The typical findings of osteopetrosis are demonstrated. The skull of this 5 year old child shows generalized sclerosis which involves the mandible and also the cervical spine.

TABLE I

Congenital Cartil	aginous Dysplasias			
	Skull Configuration (and/or Appearance)	Cranial Vault	Base	Facial Bones
Achondroplasia	Frontal bulge and sunken nose	Dilated vault; lips of anterior fontanel may be everted	Constricted base; nar- rowing of the foramen magnum may occur	Receding maxilla and protrud ing jaw; unerupted teeth
Osteochondrodys- trophy	Occasional hydro- cephaly			Delayed eruption of the teeth
Chondroectodermal dysplasia				Dysplastic changes of the teeth with malocclusion; enlarge- ment of maxilla and underde- veloped jaw; submaxillary cal- cifications at times
Chondromatosis Externa Interna	No skull abnormalities	Increased digital markings in the frontal area	Deep posterior fossa	
Hypophosphatasia	Uncalcified bones; craniostenotic shape	Wide, irregular sutures and bulg- ing of anterior fontanel; prema- ture closure later		Premature shedding of deciduous teeth
Osteopetrosis	Sclerotic bones	Brittle and stony calvarium	Smaller foramina; obliteration of mas- toids and sinuses	Underdeveloped teeth with obliterated pulp cavities
Congenital Perio	osteal Dysplasias			
Osteogenesis imper- fecta	Flat and broad shape; uncalcified bones; fibrous bag	Thin calvarium, wide sutures and fontanels; wormian bones	Occasional platy- basia; sclerosis of petrous pyramid at times	Dentinogenesis imperfecta; absent pulp chambers and root canals; poorly formed dentin
Melorheostosis	Unilateral bossing of the parietal and temporal areas		Enlargement of one-half of the mandible, sphenoid and maxilla	

entiation between the tables and diplöe is absent. The foramina of the skull bones tend to be smaller<sup>7</sup> and there is obliteration of the sinus cavities and mastoids. Fractures of the cranial vault are often present (Fig. 3). The teeth may show defects due to underdevelopment with obliteration of the pulp cavities. Periodontal and periapical infections are not uncommon in these patients and may lead to osteomyelitis of the jaws.<sup>26</sup>

## CONGENITAL PERIOSTEAL DYSPLASIAS (TABLE I)

#### OSTEOGENESIS IMPERFECTA

As bones of membranous origin are affected in this condition, the appearance of the skull may be typical and striking. There is defective mineralization of the cranial vault, and in the severe congenital form the

skull of the newborn appears as a fibrous bag with marked thinning of the calvarium, wide sutures and fontanels. Platybasia occurs occasionally.1,6 With progressive development, isolated areas of bone mineralization give rise to multiple wormian bones, giving the skull the so-called "mosaic" appearance (Fig. 4, A-D). This pattern predominates in the posterior parietal and occipital areas. The skull tends to become flat and broad as the child grows. In the so-called "tarda" types, the disturbed ossification of the calvarium is manifested by the presence of wide sutures,2 particularly the sagittal and lambdoid. Sclerosis of the petrous portion of the temporal bone is said to occur in 6 per cent of cases. 15

The teeth show abnormalities similar to those of the so-called dentinogenesis imperfecta which consists of the absence of the

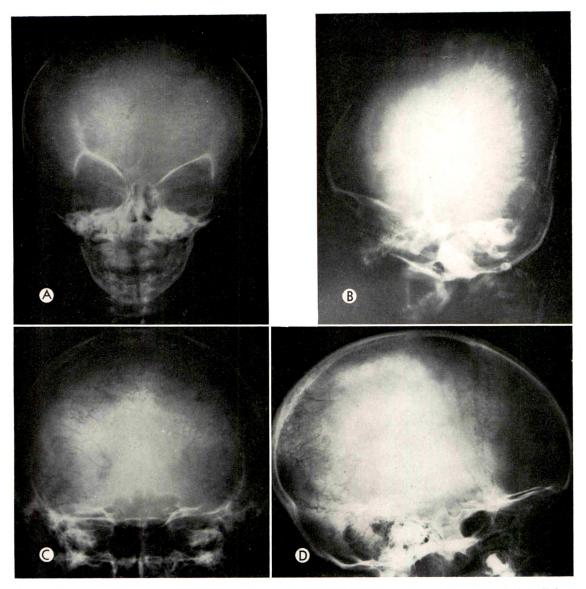


Fig. 4. Two patients with osteogenesis imperfecta. (A and B) This child was born with the typical skull findings of this disease. The vault is dilated and markedly thinned. The "mosaic" pattern produced by multiple wormian bones is noted. (C and D) The same findings are noted in this patient with the "tarda" type of osteogenesis imperfecta. The vault has ossified well and shows multiple wormian bones. The skull diameters are increased.

pulp chambers and root canals in teeth which are translucent or yellowish and have poorly formed dentin.<sup>26</sup>

#### MELORHEOSTOSIS

Skull changes may occur in cases of melorheostosis. A case reported by Franklin and Matheson<sup>14</sup> presented right sided skull involvement with bossing of the parietal and temporal bones and enlargement of the

right half of the mandible, sphenoid and maxilla.

# MISCELLANEOUS DYSPLASIAS (TABLE II) LIPOCHONDRODYSTROPHY

More than 25 per cent of the patients with gargoylism have small and short skulls,<sup>5</sup> but there are some typical skull findings in this dysplasia. The skull is more

TABLE II

Miscellaneon	us Dysplasias			
	Skull Configuration (and/or Appearance)	Cranial Vault	Base	Facial Bones
Lipochondrodys- trophy	Large and asymmetric; sometimes hydrocephalic	Wide coronal suture; increased digitations; lips of anterior fontanel may be everted	Elongated pituitary fossa	Large mandible with alveolar hypertrophy; square or notched mandibular condyle
Marfan's syndrome	Long skull with prominent supra- orbital ridges	Frontal bossing		Protruding jaw; high, narrowed palate; long and separated teeth
Cleidocranial dysostosis	Cube shape	Thin calvarium with opened fon- tanels; prominent frontoparietal and temporal areas; wormian bones are present; increased dig- itations	Narrowed base	Underdeveloped facial bones maxillary sinuses absent; de- layed root resorption and de- fective dentition
Engelmann's disease		Areas of sclerosis	Areas of sclerosis; de- fective ossification at the lambdoid suture	
Craniometaphyseal dysplasia	Generalized thick- ening of the bones	Prominent frontal and occipital areas	Obliteration of mastoids and sinuses	
Fibrous dysplasia		Widened diplöe with cystic defects	Sclerotic changes	
Papillon-Leage- Psaume syndrome			Steep sphenoid ridges; deep posterior fossa	Cleft palate, hare lip; hypoplastic, retrognathic jaw; dental malplacement
Apert's disease	Increased vertical and decreased an- teroposterior diam- eters; flat occiput; craniostenosis at times	Skull vertex at anterior fontanel; wide fontanels; thin calvarium; increased digitation in frontal area; vertical crest at the metopic suture reported	Short anterior fossa; elevation of sphenoid wings; deep mid- and posterior fossae	Short face; hypoplastic maxilla; high, arched palate; malformed teeth
Crouzon's disease	Deformed skull	Premature coronal synostosis	Basilar kyphosis	Dysplastic facial bones; hyper- telorism; small maxilla and large jaw; unerupted teeth present; beaked nose, shallow orbits
Mongolism		Thinned calvarium		Underdeveloped frontal sinuses; hypoplastic facial bones; small and deformed teeth

often large and sometimes asymmetric, showing a wide coronal suture and increased digitations at the frontal and parietal areas. The pituitary fossa is elongated in the anteroposterior diameter and may adopt the so-called "mandolin" or "shoe" shapes. These configurations are seen in Hurler's disease but are not pathognomonic and occur in other bone dysplasias, as well as in normal cases (Fig. 5,  $\mathcal{A}$  and  $\mathcal{B}$ ).

Over a third of the cases show hydrocephalus with signs of intracranial pressure. The lips of the anterior fontanel may be everted. The mandible is large, and hypertrophy of the alveolar ridge occurs with

irregular and delayed dentition.<sup>13</sup> A recently described sign<sup>16</sup> is present in the mandibular condyle, which shows a square or notched shape typical of this condition.

#### MARFAN'S SYNDROME

The skull is long and the supraorbital ridges are prominent in this condition. There may be frontal bossing and the eyes appear sunken. As a rule the jaw is pointed and protrudes forward; in some patients the opposite is true and there is recession of the jaw with malocclusion.<sup>18</sup> The palate is high, narrow and arched; the teeth are long and separated (Fig. 6).<sup>19,28</sup>

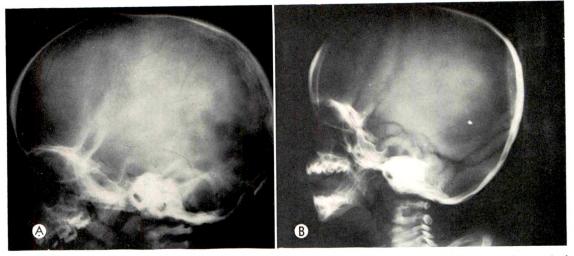


Fig. 5. (A) Note the large skull with everted lips of the anterior fontanel in this child presenting typical facial features of gargoylism. (B) Other features of this condition are seen on this roentgenogram. The sutures are wide and a "shoe" shaped sella turcica is demonstrated.

#### CLEIDOCRANIAL DYSOSTOSIS

A prominent feature of this condition is the marked craniofacial malformation. Due to the delayed ossification of the skull, the fontanels are open and may remain so for life. The cube-shaped skull shows prominent frontoparietal and temporal eminences with narrow base and a thin calvarium with increased digital markings. Wormian bones are present as a rule.<sup>27</sup> The facial bones are



Fig. 6. There is frontal bossing, dolichocephaly and prominent digitations in this skull of a patient with Marfan's syndrome. A receding jaw and malocclusion are also demonstrated.

poorly developed, the root of the nose is depressed and the maxilla is underdeveloped. The maxillary sinuses are small or absent.

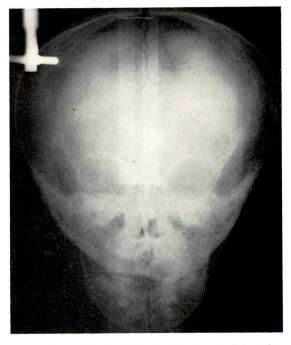
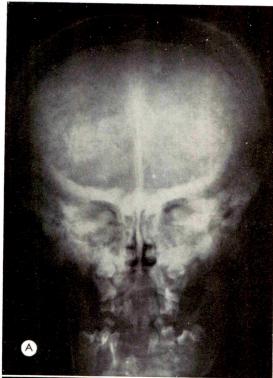


Fig. 7. In cleidocranial dysostosis the skull is cubeshaped as shown on this roentgenogram. The vault is thin and the fontanels have remained open. Wormian bones could be seen on the original roentgenogram. The maxilla is underdeveloped and the antra are small. Supernumerary teeth are present.



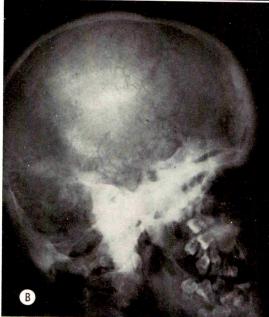


Fig. 8. (A and B) Roentgenograms showing the typical findings of craniometaphyseal dysplasia (see text).

A constant feature is the delayed resorption of the roots of the primary teeth asso-

ciated with defective eruption of the permanent teeth. Various deformities and supernumerary teeth are always present (Fig. 7).<sup>26</sup>

#### ENGELMANN'S DISEASE

The skull in these patients shows areas of thickened and sclerotic bone throughout. The facial bones as well as the remainder of the skull appear normal. Caffey³ refers to areas of defective ossification occurring at the lambdoid suture. As the child grows, these areas are not seen, probably because they become sclerotic.

#### CRANIOMETAPHYSEAL DYSPLASIA

The typical findings of this condition have been described elsewhere. The salient features are: generalized thickening of the cranial and frontal bones with predominance at the frontal and occipital areas, and obliteration of the diplöe, paranasal sinuses and mastoid cells (Fig. 8, A and B).

#### FIBROUS DYSPLASIA

Two main types of involvement are noted in patients with this disease: radio-lucent or cystic and sclerotic. More often both types are found in the same patient. The cystic type tends to be localized and unilateral. There is widening of the diplöe at the expense of the outer table of the calvarium, which is the common location of this type. The sclerotic variant is rather diffuse and occurs at the skull base and sphenoid wings.<sup>17</sup> The involved bone appears thick, dense and sclerotic (Fig. 9).

#### PAPILLON-LEAGE-PSAUME SYNDROME

A newly reported congenital dysplasia has been found in young female patients who show congenital anomalies of the hands and mouth.<sup>23</sup> Cleft palate and hare lip are present and the skull shows steep sphenoid ridges and a deep posterior fossa. A hypoplastic and sometimes asymmetric and retrognathic mandible is present together with marked dental malplacement (Fig. 10).

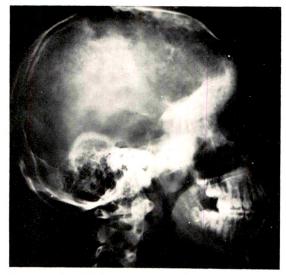


Fig. 9. The skull of a patient showing the mixed type of fibrous dysplasia. Areas of sclerotic, dense bone are seen alternating with radiolucent patches of cystic-like bone.

#### APERT'S DISEASE

The skull findings in cases of acrocephalosyndactylism are typical and consist of increase of the vertical and decrease of the anteroposterior skull diameters. The skull

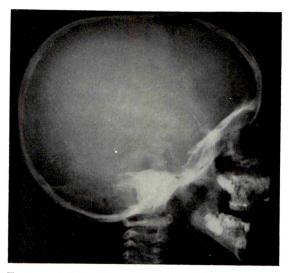
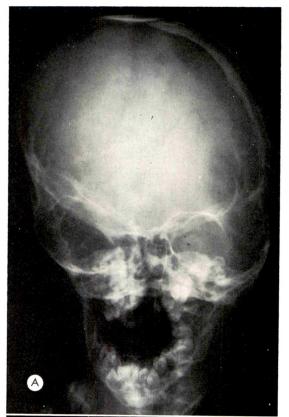


Fig. 10. A hypoplastic jaw, steep sphenoid ridges and a deep posterior fossa, accompanied by cleft palate and hare lip are found in patients with this newly described dysplasia. Congenital anomalies are found in the mouth and hands. The entity was first described by Papillon-Leage and Psaume.



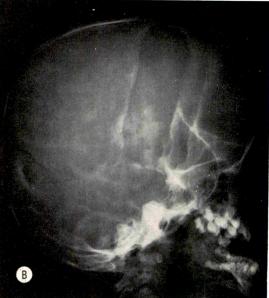


Fig. 11. (A and B) Roentgenograms showing the typical findings in the skulls of patients with Apert's disease. A surgical defect is noted in the left parietal area.

vertex is at the anterior fontanel and the occiput is flat. The fontanels are wide and the calvarium is thin with a pronounced increase of the digital markings in the frontal region. The anterior fossa and the face are shortened due to the elevation of the sphenoid wings. The mid- and posterior fossae are deep.<sup>20</sup> A vertical crest has been described occurring at the site of the metopic suture.<sup>8</sup> The maxillae are hypoplastic and show crowded and malformed teeth. The palate is high and arched. Craniostenosis may be present (Fig. 11, A and B).

#### CROUZON'S DISEASE

Patients with craniofacial dysostosis have cranial deformities produced by premature coronal synostosis combined with basilar kyphosis and dysplastic changes of the facial bones: the maxilla is hypoplastic and the jaw appears large; both show unerupted teeth. Hypertelorism is present as well as shallow orbits and a beak-shaped nose. 10,21

#### MONGOLISM

Mild dysplastic changes are found in the skulls of mongoloid patients. In a recent report<sup>25</sup> marked thinning of the calvarium and the lack of development of the frontal sinuses are described. The facial bones are hypoplastic and the teeth are small and deformed.

#### SUMMARY

A brief description of the roentgenologic features present in the skulls of patients with bone dysplasias is presented. It is postulated that familiarity with these findings will assist the radiologist in differentiating some bone dysplasias from borderline and unrelated conditions.

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#### NEURORADIOLOGIC POTPOURRI IN INFANTS AND CHILDREN\*

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In INFANTS and young children, failure to thrive, convulsions, vomiting, retardation and/or regression of motor development are common symptoms of central nervous system origin which, in our opinion, require a complete neuroradiologic work-up. Advances in pediatric neurosurgery permit restoration to the family circle of a number of infants and children who a decade ago would have required institutionalization or who would have died.

Frequently, the physician in taking the history from the parents will be able to recognize that the problem presented points to a lesion in the brain or spinal cord. The physical examination may be negative or may reveal positive findings which in themselves rarely indicate the true nature of the lesion. It is incumbent on us as radiologists to identify as far as possible the nature of the lesion and to assist the clinicians in the decision as to whether anything can or should be done for the patient. Early diagnosis is important because irreversible damage may occur if the process is permitted to continue.

This paper encompasses a few of the more interesting neuroradiologic problems referred to State University of Iowa Hospitals for evaluation. Of necessity, we have excluded cases of hemisphere subdural hematomas; meningoceles with and without bony defects and the Arnold-Chiari malformation commonly associated with these; hypoplasia of the cerebellum; tuberous sclerosis; porencephaly; craniosynostosis; Sturge-Weber malformation; most brain tumors and minor congenital anomalies such as cavum veli interpositi, absent septum pellucidum, cavum septi pel-

lucidi, cavum vergae and agenesis of the corpus callosum.

#### REPORT OF CASES

The first 3 cases are those of maldevelopment of the structures of the posterior fossa—so-called Dandy-Walker malformation. These vary in the degree of severity. This anomaly has been reported in association with agenesis of the corpus callosum.

CASE I. T. T., a boy aged 9 years, was admitted because of an enlarging head since birth, together with mental and physical retardation. There had been episodes of severe headache, nausea and retching which increased in frequency recently. At the time of admission he had such an episode for I week. This was the most severe he had endured. On examination the skull circumference was 67.5 cm. The motor power, in general, was poor but sensation was intact, and there was no hyperreflexia. The initial impression was obstructive hydrocephalus. On the day after admission ventriculograms were obtained following removal of 3,025 cc. of ventricular fluid. The findings are shown in Figure I, A and B. On the following day a craniectomy was performed, at which time it was noted that the fourth ventricle was wide open and large, and that there was an absence of the vermis of the cerebellum with small cerebellar hemispheres about one-half normal size. There was no communication between the enlarged fourth ventricle and the cervical subarachnoid space. In addition, there was some adherence of the arachnoid to the cerebellar hemispheres. Immediately upon closure of the dura, respiration ceased and the patient died. At necropsy the findings described above were confirmed.

Case II. J. S., a 20 month old girl, was first seen at the University Hospital in 1959 because of a large head which had increased somewhat in size over the previous 3 or 4 months. She had not yet learned to walk unassisted, but aside

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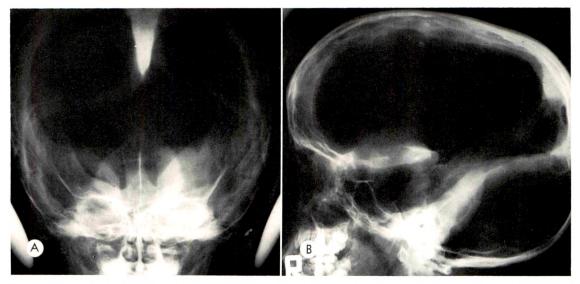


Fig. 1. Case I. (A and B) Dandy-Walker malformation. Ventriculograms showing tremendous dilatation of the lateral ventricles, elevation of the transverse dural sinuses and a large air-filled posterior fossa which represents the dilated fourth ventricle. None of the air passed into the upper cervical canal on any of the ventriculograms.

from being "fussy" she had gained and grown normally in relationship to her siblings. When seen again in January of 1961, it was noted that her psychomotor development had proceeded at a fairly normal rate, but that her head size had increased too rapidly. The head circumference was 61.0 cm. No abnormal reflexes were noted and there was no ataxia. Ventriculography was done following removal of 200 cc. of cerebrospinal fluid. The findings are shown in Figure 2, A and B and Figure 3. Three days later a ventriculo-atrial shunt was performed. Up to the present time her postoperative state has been one of bouts of nausea, vomiting, somnolence and generalized central nervous system depression. However, the ventriculo-atrial shunt has been working quite well.

Case III. R. A. R., a 9 year old girl, complained of vomiting and intermittent pain in the abdomen since the age of 7 years. Clinically, it was felt that she might have "abdominal epilepsy" because of a history of "staring" spells. Routine skull roentgenograms are shown in Figure 4, A and B. Pneumoencephalographic studies are shown in Figure 5, A and B. The unusual feature of this examination was the passage of air from the spinal subarachnoid space to the ventricular system and cerebral subarachnoid spaces, which would militate against an atresia. However, the roentgenograms show

that this did occur. The dermal sinus ended blindly in the dura. A cerebellar craniectomy revealed an occlusion to the exits of the fourth ventricle, nondevelopment of the vermis, hypoplastic cerebellar hemispheres, and a huge fourth ventricle. There was a small opening in the membrane that separated the fourth ventricle from the cervical subarachnoid space. Upon resection of this membrane, there was an immediate gush of cerebrospinal fluid from above. One month later there was evidence of increasing hydrocephalus, recurrent abdominal pain and vomiting. A ventriculo-caval shunt was performed causing these symptoms to disappear. The patient has been seen recently with a story of intermittent bouts of abdominal pain and vomiting whenever the shunt became obstructed. However, she has grown and developed normally, and is attending school.

Comment. In these 3 representative cases, there was a failure of descent of the transverse dural sinuses, absent cerebellar vermis, small cerebellar hemispheres, and an enlarged fourth ventricle. As in the majority of our cases, a complete block of the exits of the fourth ventricle was demonstrated (Case I and II). A communication between the spinal subarachnoid space and the fourth ventricular "cyst" demonstrated

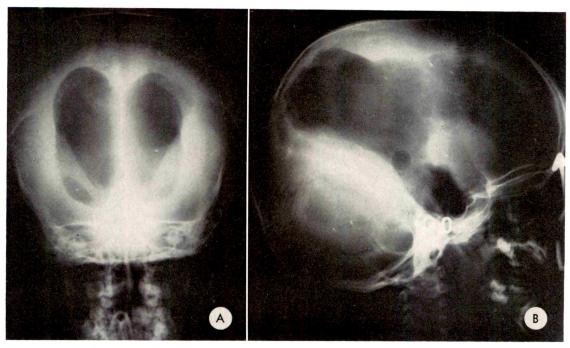


Fig. 2. Case II. (A and B) Dandy-Walker malformation. Ventriculograms showing less dilatation of the lateral ventricles, but with considerably more elevation of the transverse dural sinuses than seen in Figure 1, A and B.

on pneumoencephalograms was encountered in only 2 cases (Case III). Interestingly enough, in these 2 cases there were no clinical signs of increased intracranial pressure or increasing hydrocephalus.

A shunting operation should be done as early as possible in these patients in order to arrest the hydrocephalus and to relieve symptoms.

CASE IV. M.S., a 20 month old boy, was examined because of a rapidly increasing head size. He was born with a head circumference of 35.5 cm. There was no history of infection. On physical examination there was no evidence of a chorioretinitis or cytomegalic inclusion disease. The head circumference was 47.5 cm. At ventriculography 475 cc. of cerebrospinal fluid was removed. The ventriculograms are shown in Figure 6, A and B. A choroid plexectomy was planned and 3 days later a right temporal craniotomy was performed. Just beneath the dura there was a pasty yellow, thickened membrane which was felt to represent leptomeninges, cortical tissue, and an old inflammatory process. There was no falx and no septum pellucidum; only the basal ganglia were found to

protrude into the ventricle, and were covered with a fibropurulent membrane. The choroid plexuses were not satisfactorily visualized, since they were covered by the fibropurulent mem-



Fig. 3. Case II. Lateral ventriculogram with the head down demonstrating the inferior portion of the fourth ventricle. No air has passed into the upper cervical canal.

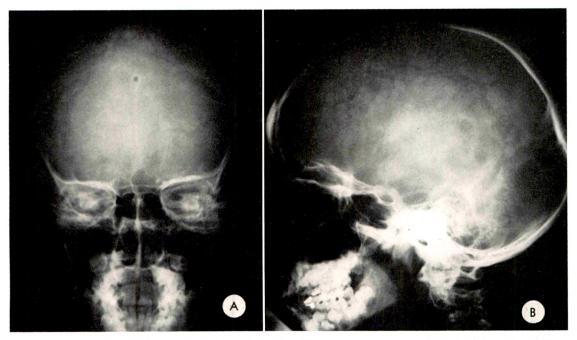


Fig. 4. Case III. (A and B) Dandy-Walker malformation. These roentgenograms of the skull show no evidence of increased intracranial pressure, but there is elevation of the transverse dural sinuses. Note the foramen in the midline of the occipital bone which is connected to a dermal sinus.

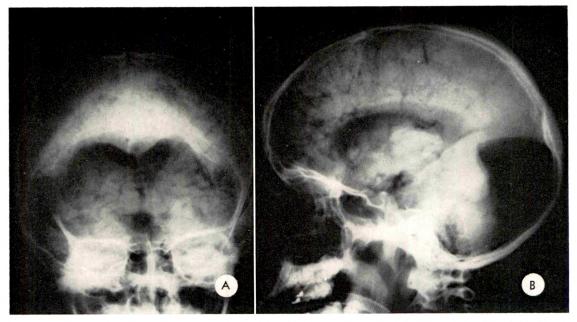


Fig. 5. Case III. (A and B) Pneumoencephalograms demonstrating only mild dilatation of the lateral ventricles and a large air-filled posterior fossa. The transverse dural sinuses are elevated. It is noteworthy that the ventricular system and subarachnoid spaces were filled by air introduced into the lumbar sac.

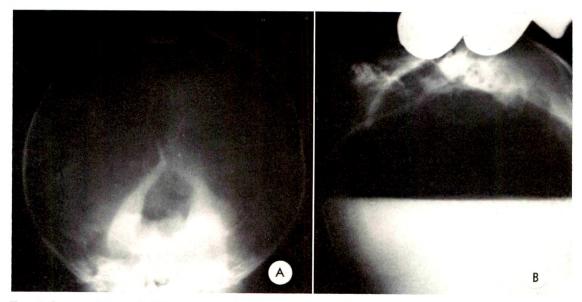


Fig. 6. Case IV. (A and B) Hydranencephaly. Ventriculograms showing tremendous dilatation of the lateral ventricle with absence of cerebral cortex and white matter. Note the shadow of the third ventricle within the mass of basal ganglia. This malformation could be primary or secondary to a prenatal infection.

brane and thus were not removed. The histologic diagnosis was fibropurulent membrane and acute meningitis with fibropurulent exudate. All cultures were sterile.

Comment. This is a case of hydranencephaly. This could be either a primary malformation (single lateral ventricle) or secondary to a prenatal infection, type or cause unknown.

CASE v. J.K.W., a 13 year old girl, presented a confusing history of headache, stiffness and pain in the neck, and vomiting. Turbid fluid was removed from the lumbar subarachnoid space; meningitis was diagnosed and treated successfully. Two months later a history of a long standing, intermittently draining occipital cyst was obtained. The skull roentgenograms are shown in Figure 7, A and B. Ventriculograms (since lost) were reported as follows: "Air and opaque contrast ventriculograms demonstrate symmetrical dilatation of the lateral and third ventricles. The distal aqueduct and fourth ventricle are displaced forward. The opaque material did not pass distal to these structures. It is our impression that a dermoid cyst produces this block." On the same day a suboccipital craniectomy was performed. The occipital sinus tract was noted to extend through the skull and the dura, and expand into a cyst.

This cyst lay between the cerebellar hemispheres. In order to gain exposure, the cyst was opened and yellowish, thick material and long hairs were evacuated. The cyst extended through the cerebellum and was adherent to the floor of the fourth ventricle, and was partially removed. Histologically, this was a dermoid cyst. Cultures of the contents of the cyst showed *Staphylococcus aureus*. Postoperative treatment of the infection was carried out. This girl is now in good health.

Comment. This is the usual history of an occipital dermal sinus with intracranial extension. Commonly, a meningitis supervenes before the true nature of the lesion is suspected. Thus, it is wise to consider the possibility of this entity in cases of meningitis and obtain skull roentgenograms prior to treatment.

Case VI. D.H., a 2 week old baby, became cyanotic soon after birth and was put in an incubator with continuous oxygen for 6 days. She then developed evidence of increased intracranial pressure and vomiting. Physical examination showed a bulging fontanelle. Ventriculograms are shown in Figure 8, A and B. Operation disclosed an encapsulated hematoma over the left cerebellar hemisphere. It contained 20

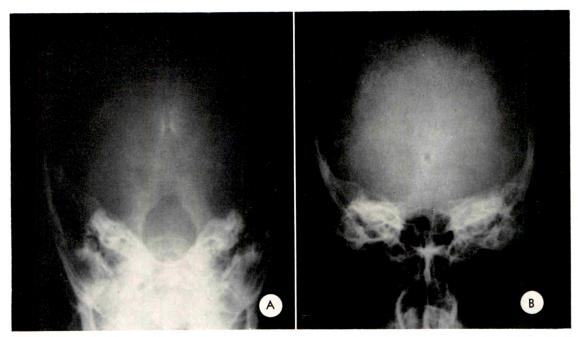


Fig. 7. Case v. (A and B) Dermoid cyst of posterior fossa. Towne and anteroposterior views of the skull showing an occipital foramen connected to a dermal sinus expanding into a dermoid cyst within the cerebellum.

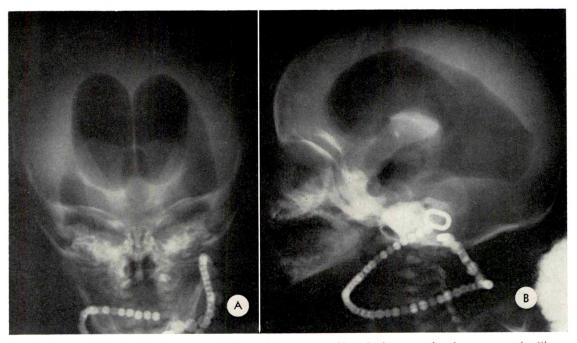


Fig. 8. Case vi. (A and B) Infratentorial subdural hematoma. Ventriculograms showing symmetric dilatatation of the lateral and third ventricles with kinking and obstruction of the aqueduct.

cc. of dirty, chocolate-colored, thick fluid. The membranes of the hematoma were lying on top of the arachnoid and were truly subdural. No vascular anomalies were noted. The membranes were subtotally removed and the flow of cerebrospinal fluid was restored. Four months later there was noted a slight increase in head size. Another ventriculogram was obtained and showed a large noncommunicating hydrocephalus. The suboccipital region was re-explored and found to have diffuse adhesions over the entire posterior fossa, probably secondary to the previous bleeding. Therefore, a ventriculo-cisternostomy was done. This was followed by a Staphylococcus albus meningitis which was successfully treated. Subsequently, because of a progressive increase in head size, a shunt was performed between the lumbar subarachnoid space and the left ureter. There has been no recurrence of the hydrocephalus on subsequent examinations.

Comment. This is a case of subdural, cerebellar hematoma followed by many complications, including a hydrocephalus and a meningitis, all of which responded to treatment.

Case VII. D.M., a previously healthy girl, developed a rapid increase in head size and loss of motor skills at 15 months of age. After examination the clinician's differential diagnosis in-

cluded subdural hematoma and cerebral palsy of the spastic type. Ventriculograms at the age of 20 months are shown in Figure 9, A and B. At exploration a 20 gm. choroid plexus papilloma was removed from the left lateral ventricle. After surgery the child was decerebrate but stabilized. Two months later because of a progressive hydrocephalus another ventriculogram was done. This showed an increase in the hydrocephalus with no air passing into the upper cervical canal. Cultures were negative. Fifteen days later a right lumbar arachnoido-ureteral shunt was performed, with control of the hydrocephalus for 3 months. Neurologic deterioration and recurrent obstructive hydrocephalus led to her death. At autopsy there was meningitis and ependymitis with adhesions obliterating the subarachnoid space around the brain stem, and thrombosis of the vertebral and basilar arteries. Pseudomonas aeruginosa and E. coli were cultured from the blood and central nervous system.

Comment. This papilloma followed the usual course of most papillomas of the choroid plexus with hydrocephalus, without evidence of obstruction to the flow of the cerebrospinal fluid, and increased intracranial pressure. This child had severe neurologic deficit prior to surgery which precluded a return to normalcy following

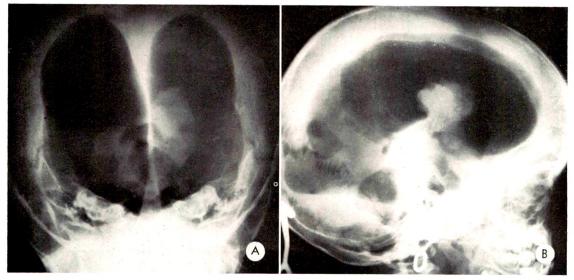


Fig. 9. Case vii. (A and B) Benign papilloma of the choroid plexus. Ventriculars outlining an intraventricular tumor within the dilated ventricular system. The ventricular system communicated with the spinal subarachnoid space.

removal of the choroid plexus tumor. Obstructive hydrocephalus recurred twice requiring shunting operations. When the diagnosis of a choroid plexus papilloma is made early, a high percentage of patients can be restored to normal by surgery.

CASE VIII. G.H., a 3 year old girl, presented with a 3 month history of a mild proptosis and sudden right external ophthalmoplegia. It was considered that this could be caused by a metastatic orbital tumor such as a Wilms' tumor or a neuroblastoma, but no evidence of either of these was found clinically. Leukemia infiltrating the orbit was also considered, but a bone marrow examination excluded this possibility. Roentgenograms of the abdomen, chest, skull, and orbits were all within normal limits at the initial examination. Outside angiograms were reported as normal. Subsequently, a corneal ulcer of the right eye, increasing proptosis, and blindness developed. One month later she had a complete right internal and external ophthalmoplegia, a left internal ophthalmoplegia, bilateral loss of vision and a complete right fifth nerve sensory loss. Right carotid angiography was repeated (Fig. 10, A and B). A right temporal craniectomy disclosed a large encapsulated extradural tumor in the floor of the right middle fossa with extension through a large bony defect into the region of the right antrum. The histologic diagnosis was anaplastic malignant neoplasm of neurogenic origin. A course of deep roentgen therapy was given to the tumor bed with a total depth dose of 2,600 r. This resulted in definite improvement in the patient, but 5 months later she died.

Comment. The difficulties in establishing the diagnosis in this case are apparent. Symptoms and signs frequently are confusing. Some delay occurred because of a false negative interpretation of a carotid angiogram. It was not until we reviewed the angiograms that a diagnosis could be made. This is the only case we have of an intracranial malignancy destroying bone in this age group.

The following 3 cases are vascular malformations occurring in infants and children.

Case IX. D.R., a 14 year old male, complained of intermittent headache for one year. Over a period of 4 days he developed severe headache, lightheadedness, vomiting and a mild left hemiparesis. There were no convulsions. On examination there was mild neck rigidity and a left hemiparesis. A lumbar puncture revealed bloody cerebrospinal fluid with xanthochromia. The impression was that the patient had a vascular tumor or an arteriovenous malformation on the right. Carotid angiograms are shown in Figure 11, A and B. A large

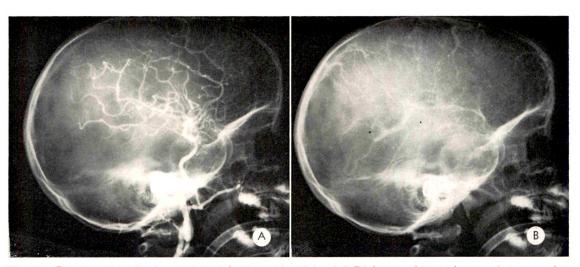


Fig. 10. Case VIII. Anaplastic neoplasm of neurogenic origin. (A) Right carotid arteriogram demonstrating distortion, straightening and erection of the internal carotid artery before its bifurcation. (B) The venogram outlines part of the tumor within the middle fossa. A bony defect is present in the greater wing of the right sphenoid.

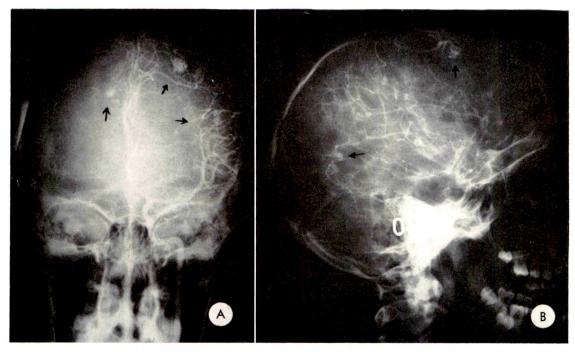


Fig. 11. Case IX. (A and B) Multiple angiomas involving the cerebral cortex. Carotid arteriograms showing the multiple angiomatous malformations of the cerebral cortex. The distortion of the anterior cerebral artery and the vessels surrounding the superior frontal angioma suggests hemorrhage or edema.

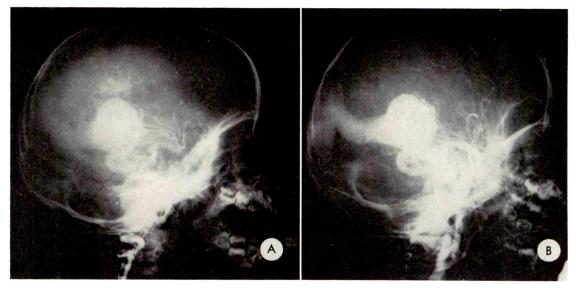


Fig. 12. Case x. (A and B) Arteriovenous malformation of the vein of Galen. Vertebral and internal carotid arteriograms demonstrate the vascular malformation. Note the large draining sinus. Both carotid systems were connected by the lesion.

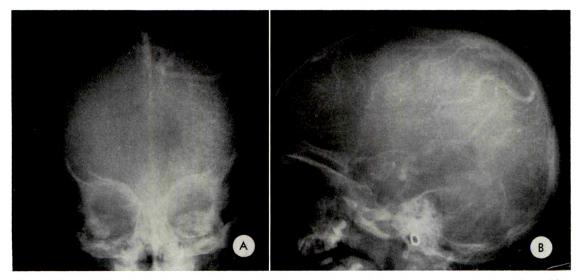


Fig. 13. Case XI. (A and B) Venous malformation in the mid-brain. Lateral venograms showing the malformation in the midline at the base and a dilated, tortuous superficial vein over the cortex.

liquid and solid hematoma was evacuated from the right frontal lobe and an angioma was resected. When discharged, the patient was asymptomatic. The histologic diagnosis was angiomatous malformation of the cerebral cortex.

Comment. This is our only case of mul-

tiple angiomas of the cerebral cortex, one of which bled and produced the symptoms and findings described above.

Case x. J.E.J., a 16 month old girl, showed signs of physical retardation since the age of 4 months. At 9 months of age the patient had her first seizure, and a diagnosis of cerebral dys-

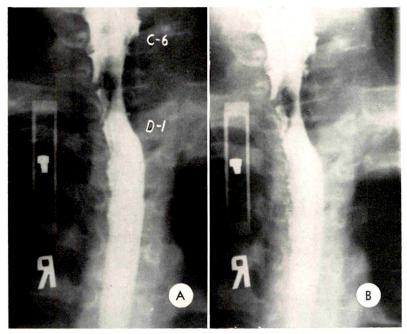


Fig. 14. Case XII. (A and B) Epidural undifferentiated sarcoma. Myelograms showing defect on the left from C-6 to D-1, with extension into the left pulmonary apex and destruction of the lateral portion of C-7.

plasia was made. At this time the mother felt that she could hear a noise in the baby when she held her close to her own body. On examination a thrill and a bruit were perceived over the right carotid and the right side of the head. Generalized hyperreflexia was present. Skull examination revealed fine linear calcifications assumed to be cortical in location. Angiographic studies of the right maxillary, vertebral and proximal portion of the common carotid artery were made. The vertebral artery was unusually large, but no other abnormality was noted. Subsequent arteriograms of the carotid and vertebral systems are shown in Figure 12, A and B. These are representative of many studies done on this child, both pre- and postoperatively. Two operative procedures were required to ligate the main feeding vessels. Four months later a communicating hydrocephalus was treated with a lumbar subarachnoid-peritoneal shunt.

Comment. Despite the presence of a bruit over the neck and upper chest there was no abnormality of the vessels in this area. This is the only case of arteriovenous malformation involving the vein of Galen that we have seen.

Case XI. O.R.D., a  $2\frac{1}{2}$  year old boy, had multiple pulsating veins in his scalp. A bruit was best heard in the left postauricular region.

There was slight enlargement of the head. Routine skull roentgenograms were felt to be compatible with increased intracranial pressure, but no abnormal intracranial calcifications were demonstrated. A pneumoencephalogram revealed symmetric dilatation of the ventricular system. Left carotid angiograms are shown in Figure 13, A and B. Right retrograde brachial arteriography failed to delineate the vessels of the malformation, and was followed by thrombosis of the brachial artery.

Comment. This case represents a venous malformation in the mid-brain. No therapy was carried out because of the failure to identify the vessels supplying the malformation.

The following 3 cases concern the use of myelography in the diagnosis of lesions involving the spinal cord and adjacent structures.

Case XII. G.D., a 10 year old boy, suffered a linear skull fracture in the right parieto-occipital area I year previously without neurologic deficit. Six months later he developed tingling, numbness and progressive weakness of the left upper extremity. A left Horner's syndrome was also present. Myelograms suggested the presence of an extramedullary tumor (Fig. 14,  $\Lambda$  and B). A rare epidural hematoma or, more

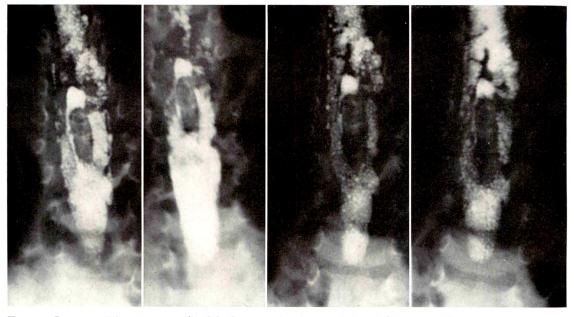


Fig. 15. Case XIII. Diastematomyelia. Myelograms showing a midline defect within the pantopaque column at T-12 to L-1 level produced by a bony spicule. Note the fusiform widening of the spinal cord.

likely at this age, a lymphoma was considered in the differential diagnosis. A cervical laminectomy revealed a highly cellular epidural tumor. It was classified as an undifferentiated sarcoma, probably reticulum cell sarcoma. Subtotal removal of the tumor was followed by irradiation, and 3,000 r in air was administered to the tumor bed and upper left lung field over a period of 17 days. This resulted in disappearance of the left upper lobe lesion and progressive improvement in his neurologic status.

Case XIII. A 13 month old girl born with a clubfoot deformity had a skin dimple and hypertrichosis in the midline over the thoracolumbar region. This was associated with multiple congenital anomalies of the thoracolumbar vertebrae. The myelograms are shown in Figure 15. At operation a spicule of bone penetrated the dural sac and transfixed the spinal cord.

There were two dural sacs and hemicords on each side of the spicule. The spinal cord was mobilized by removal of this bony spicule. Neurologic disorders were not present in this case, but the hypertrichosis and the clubfoot suggested the presence of an underlying spinal cord anomaly.

Case XIV. G.O., a 21 month old infant held her neck rigidly and cried on movement of the head. She lost weight and developed weakness in both legs. The neck was held in extension and slightly turned to the left. At the time of admisssion she was febrile and had leukocytosis. The spinal fluid was xanthochromic and contained 37 cells and a total protein of 113 mg. per cent. A high cervical or medullary neoplasm was suspected. Myelograms (Fig. 16, A and B) confirmed the diagnosis. An occipital craniectomy revealed a bulging medulla which had

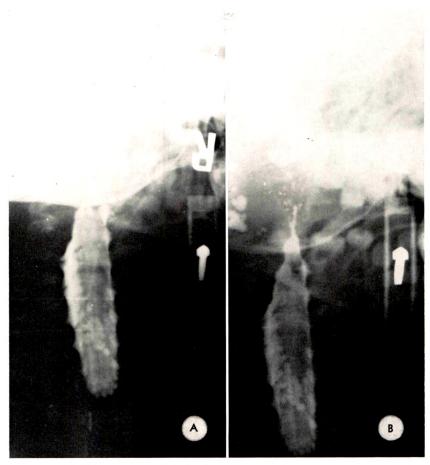


Fig. 16. Case xiv. (A and B) Histocytosis of the nonlipid type. Myelograms showing a defect in the high cervical canal on the left side produced by the intradural extramedullary mass protruding from the posterior fossa.

been rotated from left to right by an underlying tumor. The biopsy specimen was diagnosed as histiocytosis of the nonlipid type. Three weeks later a total of 1,500 r in air was given to the occipital and cervical regions. Three months later there was a spastic tetraparesis, involvement of several cranial nerves and of the corticospinal tracts. The child died. No autopsy was obtained.

Comment. These 3 cases illustrate the value of utilizing myelography in the diagnosis of suspected lesions of the spinal cord and its surrounding structures. Myelography is particularly helpful in determining the extent and level of the lesion when it cannot be ascertained clinically.

# SUMMARY

These 14 cases were chosen from our extensive neuroradiologic files to illustrate several points:

1. History and physical examination

may implicate the nervous system, but rarely do they accurately localize the lesion.

- 2. Localization of central nervous system disease frequently depends on roentgenographic examination.
- 3. Club foot deformity, hypertrichosis, Horner's syndrome in association with hemiparesis may be suggestive of spinal cord lesions.
- 4. In meningitis, skull roentgenograms should be obtained prior to treatment.
- 5. Advances in radiology and neurosurgery permit amelioration or cure of many diseases formerly thought to be incurable.

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# POSTERIOR FOSSA TUMORS IN INFANTS AND CHILDREN\*

By EVERT KRUYFF, M.D., and J. D. MUNN, M.D. TORONTO, ONTARIO

HE roentgenographic signs of intracranial space-occupying lesions in infants and children differ from those in adults due to the fact that at this very early age the growing skull is flexible and can adjust its size and shape. This response to a space-demanding, expansive process itself and to its obstructive influence which interferes with proper flow of the cerebrospinal fluid is especially seen in lesions which continue to develop for many years before normal physiology is impaired to a degree incompatible with normal function. The purpose of this paper is to present a study of 173 cases of posterior fossa tumors in infants and children to determine to what degree skull changes take place in the presence of these tumors and to describe valuable signs for their localization as well as for differentiating between benign and malignant lesions in general, and between astrocytoma, medulloblastoma and cerebellar sarcoma in particular.

# AIR STUDY FINDINGS

It is usually possible to localize a spaceoccupying lesion in the posterior fossa by ventriculography or pneumoencephalography. The latter is the method of choice with which to begin the examination, notwithstanding the presence of increased intracranial pressure. Pneumoencephalography is a simpler procedure, and one avoids the disadvantages of ventriculography. It shows important cisterns and often the fourth ventricle can be filled. It is a safe procedure as long as no cerebrospinal fluid is withdrawn. In many instances the appearance of the fourth ventricle is the crucial factor in determining the exact location of a posterior fossa tumor. The demonstration of a shift of the fourth ventricle away from the midline, anteriorly or posteriorly, upwards or downwards in relationship to Twining's midpoint, is of important significance. Roentgenograms in the posteroanterior, reversed Towne, and lateral projections and, occasionally, laminagrams may need to be made.

In tumors of the fourth ventricle, papillomas and choroid plexus carcinomas, considerable dilatation of the fourth ventricle is demonstrated with main signs of concave walls and filling defects, but without displacement of the fourth ventricle itself.

The diagnosis of a prepontine lesion is established by the backward displacement of the fourth ventricle, the cisterna pontis, and the interpeduncular cistern. Pneumoencephalography is the procedure of choice in these cases.

A tumor of the pons presents the roent-genographic picture of backward displacement of the fourth ventricle which generally appears to be small with convexity of its floor and a flattened pontine cistern. Depending on the size and location, tonsil herniation, elevation of the posterior floor of the third ventricle, flattening of the posterior perforated area, and sometimes an elevated, widened cisterna ambiens are visualized. Large fourth ventricle and cerebellar tumors will also present one or more of these findings, together with elevation of the collicular plate and widening of the cisterna venae magnae.

In cases of asymmetric development of pons tumors, the floor of the fourth ventricle may be shifted partially across the midline (Fig. 1, A and B). This finding can simulate a small ependymoma arising from the floor of the fourth ventricle. The dis-

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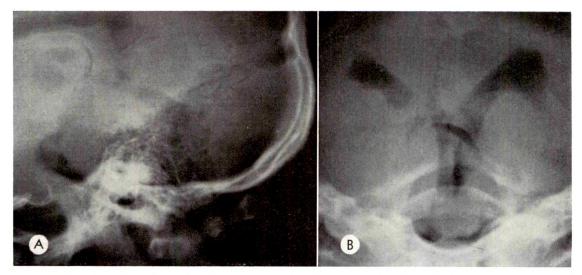


Fig. 1. Pneumoencephalograms showing an asymmetric pons tumor. (A) Lateral view shows stretching of the aqueduct, slight displacement posteriorly of the fourth ventricle and an unsharp floor of the fourth ventricle. (B) In the posteroanterior view the fourth ventricle is not enlarged. Its floor is pushed superiorly in an oblique way.

tinguishing feature, however, is that in the latter the fourth ventricle appears to be dilated.

Pontine tumors are nearly always gliomas which prove to be fatal. However, where there is considerable backward displacement of the fourth ventricle without a shift from the midline, a pontine cyst should be considered (Fig. 2), since in these cases neurosurgical intervention has proved successful. A puncture of the cyst appears to have improved the prognosis in 2 patients of our series,\* one of whom also had radiation therapy. Large ependymomas arising from the floor of the fourth ventricle can simulate a pons tumor (Fig. 3A), but can be distinguished on the posteroanterior roentgenograms by demonstration of a bilaterally wide split-like fourth ventricle (Fig. 3B) resembling the shape of a "Roman arch." Figure 4, A, B and C shows still another appearance of a fourth ventricle ependymoma.

An interesting example of differentiation is shown in Figure 5, a case with a persistent septum occluding the foramen of Magendie. Here, the Twining's midpoint

projects into the fourth ventricle. The bulging concave floor and roof of the fourth ventricle ("hot water bottle appearance") are important features.

In low pontine and medulla tumors, the fourth ventricle is pushed backwards and also upwards to a considerable degree but

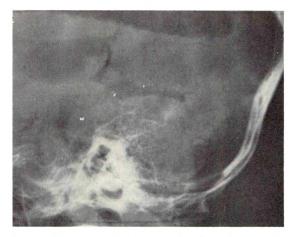


Fig. 2. Pneumoencephalogram showing a lower pons tumor. At operation (Dr. B. C. Hendrick) a large cyst was found arising from the pons, with xanthochrome fluid. Typical elevation of the floor of the fourth ventricle and backward displacement are noted. The fourth ventricle itself is not enlarged. The cisterna pontis is flattened.

<sup>\*</sup> Personal communication (Dr. B. C. Hendrick).

there is no definite enlargement of the fourth ventricle (Fig. 6, A and B).

Pontine angle tumors are very rare in children. Pneumoencephalography is the method of choice for detecting them. In fact, in order to differentiate pontine angle tumors from those of the posterior fossa, it is necessary to have a thorough knowledge of the value of pontocerebellar cisterns so as to determine the presence of a shift of the fourth ventricle and of the aqueduct or the absence of a shift. This information cannot be obtained from ventriculography.

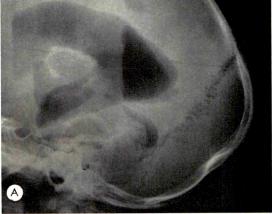
In cases of dermoid cysts, a preoperative diagnosis is usually possible. Of 6 patients in our series, only I did not show the typical skull defect. (Three had congenital anomalies of the Klippel-Feil type; I of these also presented a cleft palate).

Not included in our study are abscesses, rare tumors arising from the bony skull or those presenting the Dandy-Walker syndrome.

Cerebellar tumors can usually be localized with well executed air studies (Fig. 7, A, B and C). We are not entirely in accord with the views of Lysholm. We have seen 2 cases of cerebellar tumors which were operated upon and in which the tumor was found on the same side as the displacement of the fourth ventricle. This displacement was due to the development of a cystic formation in the midline, pushing the fourth ventricle sideways, where a massive nodule arose deep in the cerebellar hemisphere.

# METHOD AND MATERIAL

To differentiate on air studies between the cerebellar astrocytoma, malignant medulloblastoma and the so-called cerebellar sarcoma is difficult; this is also mentioned by McRae and Elliott. It was our impression that this could be better done by a close observation of routine skull roentgenograms. We therefore reviewed 173 cases of posterior fossa space-occupying lesions observed from January 1, 1946 to March 1, 1962 at the Hospital for Sick Children. Only cases in which autopsy findings or



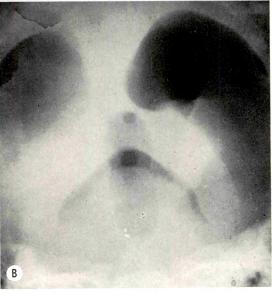


Fig. 3. Ventriculograms showing an ependymoma arising from the floor of the fourth ventricle. (A) Lateral view. The fourth ventricle is enlarged and what appears to be its floor is pushed backwards, but (B) the posteroanterior view shows this to be a large filling defect arising from the floor of an enlarged fourth ventricle, producing a "Roman arch" configuration. The fourth ventricle is not displaced out of the midline.

surgical specimens established the diagnoses were considered (Table 1).

The age distribution of patients with astrocytoma, medulloblastoma, including the so-called cerebellar sarcoma, ependymoma and pontine tumors is given in Diagrams I, II, III and IV.

In 50 astrocytoma and 34 medulloblastoma cases, roentgenograms were avail-

Table I CLASSIFICATION OF 173 INFRATENTORIAL SPACE OCCUPYING LESIONS

	Boys	Girls	Totals
A. Tumors of Nervous Tissue		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
<sup>8</sup> 1. Gliomas			
Pons			
(a) Glioma of the pons (also called polar spongioblastoma)			
Verified 19			
(b) Cysts of the pons (not biopsied) 2	12	9	21
Medulla			
(a) Glioma (cystic)	I	*******	I
& (b) Malignant glioma of noor of fourth ventricle	I	-	I
*Cerebellum and Fourth Ventricle			
(a) Cystic astrocytoma of the cerebellum	24	31	55
(b) Astroblastoma	I	0	1
(c) Medulloblastoma			
So-called cerebellar sarcoma 9	19	16	35
(d) Ependymoma	21	11	32
2. Choroid plexus tumors (papillomas) of the fourth ventricle	. 3		3
3. Acoustic nerve tumors (neurilemmoma)		I	I
B. Tumors of Mesenchymal Tissue			
(a) Hemangioblastoma		I	I
(b) Arteriovenous malformation	3	2	5
(c) Arachnoid cysts			_
subtentorial			
posterior fossa			
prepontine cyst	2	I	3
C. Tumors of Maldevelopment (development tumors)			•
(a) Dermoid cysts	2	4	6
(b) Hamartoma of the tentorium		r	I
(c) Chordoma (of the clivus)			
Malignant (metastases to the lungs) I			
Benign 2	I	2	3
In addition there were 4 subdural cerebellar hematomas.	3	I	4
Total	93	80	173

able and attention was directed particularly to (1) the splitting of the sutures, (2) the sella turcica changes, (3) the occipital emissary vein openings, and (4) the deformities of the basi-occiput, since it is in these areas that changes are most apt to occur as a result of an underlying intracranial tumor. At the same time, these areas were reviewed and compared in 21 pons tumor and 31 ependymoma cases. Other secondary signs due to increased intracranial pressure are mentioned in the literature but were not taken into account in our study. These changes can be: increase or accentuation of the digital markings, a rather subjective aspect to estimate but of importance in

the presence of widened sutures or when a comparison is made with previous roent-genograms; enlargement of the skull; demineralization of the sphenoid wings; enlargement of basal foramina; diminishing of diploic vessels after the age of 4 to 5 years; elongation of the serratae of the sutures; and localized thinning of the calvarium.

# SPLITTING OF THE SUTURES

Of importance for the occurrence of suture splitting is the child's age at which the obstruction of the cerebrospinal fluid pathways occurs. The localization of the obstruction and the rate of growth of the

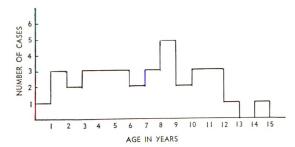


DIAGRAM I. Age distribution of 35 medulloblastoma cases (including so-called cerebellar sarcomas).

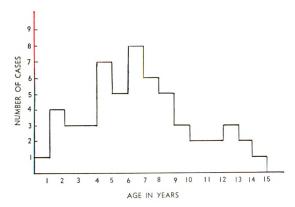


DIAGRAM II. Age distribution of 55 astrocytoma cases.

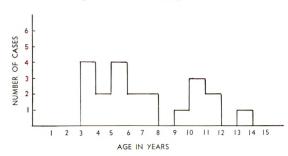


DIAGRAM III. Age distribution of 21 pontine tumor cases.

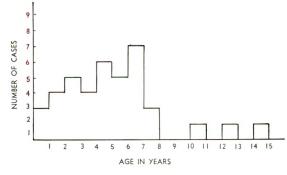
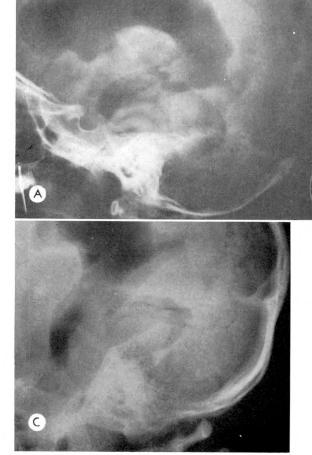


DIAGRAM IV. Age distribution of 32 ependymoma cases.

tumor are additional important factors. When a splitting of the suture is seen in infancy without other secondary signs of increased intracranial pressure in the bony skull, the term "acute splitting" is often used. However, if there is a gradual development of hydrocephalus, it is possible, especially in the infant until the age of about I to 2 years, to recognize increase in intracranial pressure by roentgenologic signs of a simple splitting of the sutures, with no actual pressure being exerted on the sella turcica or others parts of the bony skull. If the intracranial pressure increases at a rate faster than that which the sutures can accommodate, signs of chronic increased intracranial pressure will appear. In the infant skull, widening of the sella turcica entrance is seen followed by destruction of the dorsum, and in advanced cases demineralization of the clinoids with widening of the chiasmatic groove is noted. In addition, depression of the floor of the sella turcica and of the tuberculum sellae may produce the "J" shaped appearance. In the child approximately 3 to 5 years of age the splitting of the sutures becomes more difficult to assess and sellar changes are often seen in chronic cases. After the age of 8 to 10 years, splitting is infrequently noted, although it can occur. Only when the obstructive lesion grows very slowly and over a considerable period of time does splitting of the sutures appear. In addition, sellar changes are present as well. Thus, in evaluating splitting of the sutures and other signs of increased intracranial pressure in the different age groups, we wish to stress that in the infant group splitting alone is not necessarily a sign of acute increase in pressure, but can also be seen in cases of a slow developing hydrocephalus. Furthermore, splitting in the older age group is possible and favors a longstanding lesion. Not infrequently, splitting of the sutures appears in the 5 to 10 year age group, as seen in the case of a rather rapidly growing medulloblastoma. Slight changes in the sella turcica and demineralization will suggest a



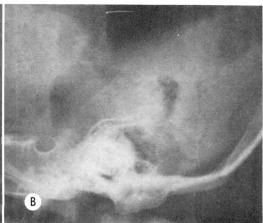


Fig. 4. (A, B and C) Lateral views of 3 patients with ependymoma showing a dilatation of the fourth ventricle plus filling defects. Here the floor can be distinguished. No shift is present.



Fig. 5. Ventriculogram of a 6 year old girl with foramen Magendie obstruction due to a congenital septum showing the typical "hot water bottle appearance." No signs of suture splitting are noted. The fourth ventricle is not displaced.

process of long duration. Tönnis and Kleinsassar<sup>8</sup> feel that the expression "suture widening" instead of suture splitting should be used. They state that no destruction of bones or sutures takes place but that there is an increase of interstitial tissue growth of the suture.

Suture splitting was seen in cases of medulloblastoma and astrocytoma in our series in all age groups. It was most pronounced in the early years of life. Suture splitting was, however, less frequent and less severe in the medulloblastoma patients over the age of 5 years, as compared to the patients with cerebellar astrocytoma.

Suture splitting in ependymoma cases was seen in all age groups, but, was of a lesser degree as compared to astrocytoma cases. In tumors of the pons suture splitting

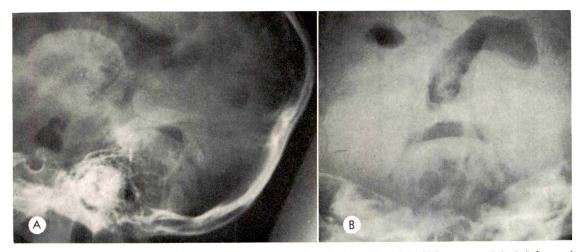


Fig. 6. Medulla-astrocytoma with a large cyst (operated on by Dr. W. Keith, February, 1962). (A) Lateral view shows the floor of the fourth ventricle pushed superiorly and posteriorly. Also the foramen of Magendie is displaced posteriorly. The cisterna pontis was difficult to fill. (B) Posteroanterior view shows the floor of the fourth ventricle pushed upwards symmetrically. The fourth ventricle is not enlarged.

was rare and when found was of a minimal degree.

# SELLA TURCICA CHANGES

The sella turcica changes, the so-called "J" shaped sella and widening of the entrance of the sella turcica, were rarely seen in patients with medulloblastoma. In cerebellar astrocytoma, the wide sella turcica was seen more often. Sellar changes were rare in cases of pons glioma and not infrequently seen in ependymoma. De-

struction of the dorsum sellae and of the clinoids was more pronounced in cases of astrocytoma as compared to cases of medulloblastoma in the over 4 year age group, although this was by no means a rare finding for the group of medulloblastoma cases. In 8 cases of astrocytoma under the age of 3 years, no definite sellar changes could be detected. In the group with pons tumors, sellar destruction was seen only occasionally. The same frequency of sellar destruction was noted in cases of astro-

Table II

Incidence of normal and wide occipital emissary vein opening in 1,000 normal cases compared with its incidence in different groups of posterior fossa space-occupying lesions

	No. of Cases	0	Occipital Emissary Vein Opening			
		Cases with Roentgenograms Available	Present		Wide	
			No.	Per Cent	No.	Per Cent
Normal skulls	1,000		79	7.9	3	0.3
Posterior fossa space-occupying lesions	173	165	65	39	30	18
Cerebellar astrocytoma	55	50	25	50	15	30
Ependymoma	32	31	14	45	3	IO
Medulloblastoma (inclusive so-called						
cerebellar sarcoma)	35	34	10	30	4	I 2
Pons tumors	21	21	5		I	
Rest	30	29	ΙI		7	

The incidence of the occipital emissary vein opening is increased in posterior fossa space-occupying lesions.

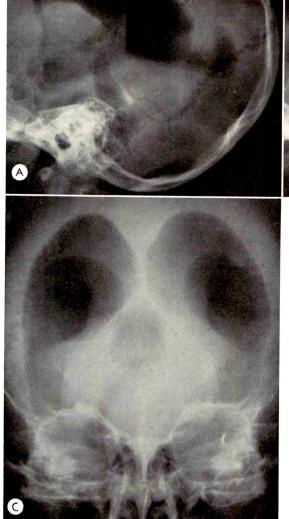




Fig. 7. Typical displacement and configuration of the aqueduct and the fourth ventricle in cerebellar tumors. (A) Lateral view showing a cerebellar medulloblastoma. (B) Lateral view showing a cerebellar astrocytoma. (C) Posteroanterior view showing a cerebellar astrocytoma.

cytoma and ependymoma over the age of 3 years. Under the age of 3 years, sellar destruction in ependymoma cases was rare.

THE OCCIPITAL EMISSARY VEIN OPENINGS

The occipital emissary vein openings are reported by several authors to be widened in cases of longstanding increased intracranial pressure. Lindblom, in his material of supratentorial and infratentorial tumor cases of all ages, obtained an incidence of 10 per cent of wide occipital emissary vein openings. Analyzing his figures, we find an incidence of 18 per cent of wide occipital emissary vein openings in his group of 60

cases of posterior fossa glioma. Thirty-nine patients had benign lesions and of this group 10 cases or 25 per cent had a wide occipital emissary vein opening. Hertz and Rosendal<sup>2</sup> noted in 153 children with supratentorial and infratentorial tumors the presence of a wide emissary vein opening, but did not mention the incidence in the malignant or the benign groups.

A large emissary vein opening denotes that a lesion has existed a long period of time, causing increased intracranial pressure (Fig. 8, A and B). Why this is so is not well understood nor proven but is likely due to the localization of the tumor.

An impairment of venous blood flow through the sigmoid sinus and jugular foramen results in bypassing through emissary veins which are thereby enlarged. They ultimately join the external jugular veins. To establish the value of the enlarged occipital emissary vein opening as evidence of chronic, longstanding increase in intracranial pressure so that a differentiation between a benign and a rapidly growing malignant cerebellar tumor could be made, we checked this emissary vein opening in a group of patients with posterior fossa tumors (Table II). Normal occipital emis-

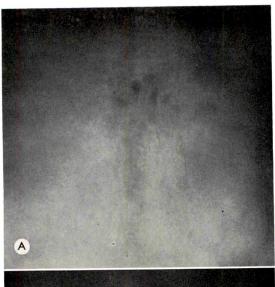
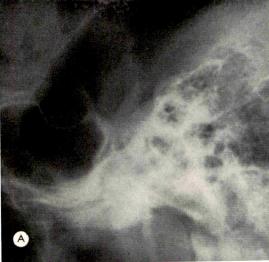




Fig. 8. (A and B) Examples of wide occipital emissary veins and wide occipital emissary vein openings in cases of longstanding increased intracranial pressure.



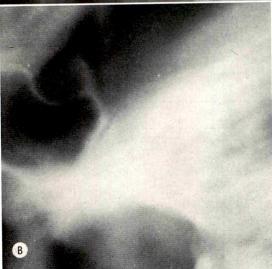


FIG. 9. (A) Lateral view showing the basi-occiput concavity in a 12 year old boy with a cerebellar astrocytoma. Note the marked curvature of the basi-occiput. The dorsum sellae is straight. The cisterna pontis and the cisterna interpenduncularis are flattened. (B) Laminagram of the same case.

sary vein openings are described as being about the size of 1–4 pinpoints seen in the Towne's projection of the skull in the region of the torcular Herophili and are usually surrounded by a faint sclerotic ring. An occipital emissary vein opening is considered enlarged when this opening is larger than 2 mm. Often loss of its sclerotic border is noted.

Table III
INCIDENCE OF OCCIPITAL EMISSARY VEIN OPENING
IN A GROUP OF 505 NORMAL SKULLS IN CHILDREN

Age	No. of Boys	Occipital Emissary Vein Opening	No. of Girls	Occipital Emissary Vein Opening
O-I	15	ı (wide)	11	I
1	10	0	24	2
2	36	I	27	I
3	29	3	2,3	2
	32	3	23	2
4 5 6	35	2	17	I
6	36	5 (one of which was wide)	h 21	3
7	29	4	9	1
8	27	4 5	15	0
9	14	2	8	I
10	15	0	3	0
II	12	2	5	0
12	10	0	3	I
13	6	0	I	0
14	5	2	2	0
15	I	0	I	0
Total	312	30	193	15

Another group of 495 children with normal skulls, of which the age and sex were not given, showed 34 occipital emissary vein openings, one of which was wide.

From a total of 1,000 normal skulls, the incidence of occipital emissary vein opening was 45 plus 34=79, or 7.9 per cent. Three cases (0.3 per cent) showed a wide occipital emissary vein opening.

The frequency of an occipital emissary vein opening is high and widening was seen in 18 per cent of our group of cases with posterior fossa tumors, the same percentage as found by Lindblom.4 In the astrocytoma cases, a widening of the occipital emissary vein opening was noted in 30 per cent of the patients as compared to 12 per cent in the medulloblastoma cases. A widening of the occipital emissary vein opening is rarely seen in cases of pons glioma. It is occasionally seen in patients with ependymoma. A widening of more than 4 mm. was seen in 10 cases of astrocytoma as compared to one case each of medulloblastoma and ependymoma, and in no case of pons tumor. In astrocytoma a widening up to 8 mm. has been recorded. In many instances a pronounced enlargement of the occipital emissary vein openings was seen in conjunction with enlargement of the occipital emissary vein channels.

Contrary to the statement of Lindblom<sup>4</sup> and Hertz and Rosendal,<sup>2</sup> wide occipital emissary vein opening was seen without splitting of the sutures in 2 cases. Table III shows the findings of a control survey of occipital emissary vein opening in a group of 1,000 consecutive normal children ranging in age from birth to 15 years of whom routine skull roentgenograms had been made for head trauma. The incidence of emissary vein opening around the torcular Herophili was 7.9 per cent. Only in 3 cases (0.3 per cent) was the emissary vein opening widened.

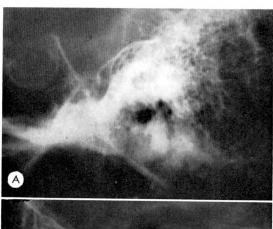




Fig. 10. (A) Lateral view showing the basi-occiput curvature in a case of ependymoma of the fourth ventricle of 5 years' duration. (B) Same case 5 years previously.

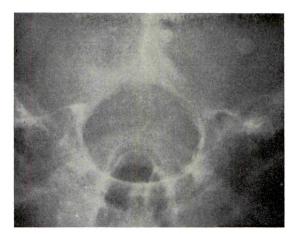


Fig. 11. Lateral displacement of the jugular tubercles in a 12 year old boy with a cerebellar astrocytoma. The sulcus of the clivus is broad and not too distinguishable from the anterior border of the foramen magnum. Compare with Figure 12.

#### BASI-OCCIPUT DEFORMITIES

These deformities, consisting of (A) basiocciput concavity and (B) tuberculum jugulare displacement, are significant signs of an expanding benign posterior fossa lesion and we believe have not been described as being of value in differentiating rapidly growing malignant cerebellar tumors.

(A) Basi-occiput Concavity. The finding of Castellano and Ruggiero, "that from the radiological point of view, the clivus, as seen on a lateral view, is the most regular and constant plane in the base of the skull," was not verified in our study with children. Orley describes the clivus as a straight line normally, but also mentions the finding of an occasionally slight regular curvature of the clivus in cases of posterior fossa tumors. He states that Rossier found a curved clivus in 14 out of 28 cases of cerebellar tumors, independent of the age of the patient or the nature of the tumor.

In 500 normal children, ranging from birth to 15 years of age, the appearance of the clivus on the lateral roentgenogram was studied by us (Diagram v) in an attempt to analyze the anterior border of the posterior fossa. A division into 5 groups was made (Table IV). The basi-occiput ap-



Fig. 12. Normal 12 year old boy. The jugular tubercles are projecting within the boundaries of the foramen magnum. The sulcus of the clivus is narrow and is distinguishable from the outline of the anterior border of the foramen magnum.

peared to be straight or minimally concave in 97.6 per cent of the children. None of the cases showed a convexity. A concavity with a depth of more than 2 mm. was seen in 4 cases (0.8 per cent).

The same grouping was used in outlining the combined structures of the dorsum sellae and clivus (Table v and Diagram v). In this group a concavity of more than 2 mm. was seen 5 times more frequently than in the study of the basi-occiput alone; however, the outline of the clivus plus dorsum sellae is less significant than the outline of the basi-occiput alone, as the concavities visualized here were produced by the configuration of the dorsum sellae, while the basi-occiput itself was straight. For the four major groups of posterior fossa tumor cases, the incidence of a straight or concave basiocciput is given in Table vi. Concavity of the basi-occiput was seen three times more often in patients with astrocytoma as com-

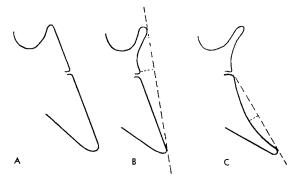


Diagram v. (A) Straight dorsum sellae and straight basi-occiput. Normal. (B) The combined clivus and dorsum sellae configuration shows a concavity due to dorsum sellae curvature. The basi-occiput remains straight. Normal. (C) The combined clivus and dorsum sellae configuration shows again a concavity, but here the basi-occiput itself presents a definite concavity. If the basi-occiput concavity is more than 3 mm., a space occupying lesion of long duration in the posterior fossa has to be considered. This basi-occiput concavity can occur in combination with a straight dorsum.

pared to those with medulloblastoma. The depth in these cases ranged from 3 to 5 mm. Those with a basi-occiput concavity depth of 3 mm. or more also showed an increased clivus-dorsum sellae curvature, but only in cases of astrocytoma were depths of the clivus-dorsum sellae concavity found to be as great as 5 to 8 mm. Figure 9, A and B shows an advanced case in which a depth of 5 mm. was noted. The normal depth is less than 2 mm.

Thus, in posterior fossa tumors, not only herniation through the foramen magnum or through the incisura tentorii can take place as a cause of volume increase, but, depending on the rate of growth of the tumor and the age of the child, the possibility exists that the volume of the posterior fossa may be increased by pressure on the bone. Evidence of this is demonstrated in the basi-occiput configuration which tends to become concave in shape (Fig. 9, A and B).

Often asymmetry of the posterior fossae was seen, but, unless severe, is of little value. It is reasonable to assume that an expanding lesion of long duration in the posterior fossa in children with slow in-

TABLE IV

POSTERIOR OUTLINE OF BASI-OCCIPUT CONFIGURATION
IN 5∞ NORMAL CHILDREN

		Boys	Girls	Total
Group 1	Straight line or minimal con-			0.0
_	cavity	301	187	488
Group 2	Concavity of 2 mm.	7	1	8
Group 3 Group 4	Concavity of 3 mm. Concavity of 4 mm.	· 4	Manag	4
	or more	-	-	
Group 5	Convex outline	******	*********	***************************************
Total		312	188	500

volvement of vital structures and with delayed total blocking of the cerebrospinal fluid pathways can produce this basi-occiput concavity. It is necessary for considerable force to take place for the basi-occiput is a rather massive piece of bone; however, at the same time thinning of the basi-occiput was usually seen. The basi-occiput was never visualized as being shorter than normal. Basi-occiput concavity of more than 2 mm. was only seen in one case of ependymoma and this was of 5 years' duration (Fig. 10,  $\mathcal{A}$  and  $\mathcal{B}$ ). It was occasionally seen in patients with pons gliomas.

(B) Tuberculum Jugulare Displacement. The Towne's projection may demonstrate changes due to increased intracranial pressure (Fig. 11). The normal skull shows the

Table V

POSTERIOR OUTLINE OF COMBINED CLIVUS AND
DORSUM SELLAE CONFIGURATION IN
500 NORMAL CHILDREN

	•	Boys	Girls	Total
Group 1	Straight line or			
	minimal concavity	243	152	395
Group 2	Concavity of 2 mm.	12	7	19
Group 3	Concavity of 3 mm.	12	5	17
Group 4	Concavity of 4 mm.		•	•
	or more	5	*******	5
Group 5	Convex outline	40	24	64
Total		312	188	500

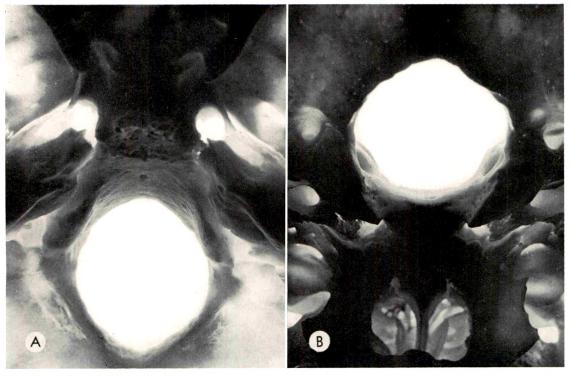


Fig. 13. (A) Photograph of a child's skull from above, taken slightly obliquely to avoid shadow projection. The jugular tubercles are projecting within the limits of the foramen magnum. (B) Photograph of the same skull as in A, taken from below, demonstrating the location of the jugular tubercles seen through the foramen magnum.

jugular tubercles being projected, at least partially, within the boundaries of the foramen magnum (Fig. 12). The medial portion of the clivus is seen as a large sulcus between the jugular tubercles and is well differentiated from the anterior border of the foramen magnum, being smaller in bilateral dimension. In photographs of a dried skull (Fig. 13, A and B), the jugular

tubercles are shown. From their position it is evident that on roentgenograms they may fall within the limits of the foramen magnum.

In cases of longstanding space-occupying posterior fossa lesions, the jugular tubercles are seen displaced laterally, out of the boundaries of the foramen magnum. The sulcus of the basi-occiput in these patients

Table VI

INCIDENCE OF THE DIFFERENT BASI-OCCIPUT CONFIGURATIONS IN FOUR MAJOR GROUPS
OF POSTERIOR FOSSA TUMORS IN CHILDREN

	No. of Cases	Rentgeno-	Straight or	Curvature Depth		
		grams Available	Minimal Curves	2 mm. and more	more than 3 mm.	
Cerebellar astrocytoma	55	50	35	16	6	
Cerebellar medulloblastoma (inclusive						
so-called cerebellar sarcoma)	35	34	29	3	I	
Pons glioma	21	2 I	17	4	I	
Ependymoma	32	31	30	I	I	

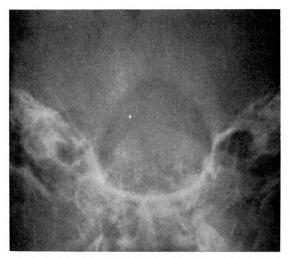


Fig. 14. Ependymoma of the fourth ventricle of 5 years' duration. The same pathologic configuration of the jugular tubercles and the sulcus of the clivus as demonstrated in Figure 11 is seen.

is broader and not very difficult to differentiate from the anterior rim of the foramen magnum (Fig. 11).

In 5 cerebellar astrocytoma cases this pathologic configuration of the jugular tubercles was found. The basi-occiput concavity was more than 3 mm. deep in these cases. In the other groups of posterior fossa tumors, this flattening of the tubercles was not demonstrated except in the case of an ependymoma of 5 years' duration (Fig. 14), which was not operated on for various reasons. These 6 patients were over 7 years of age.

In addition to the basi-occiput concavity, sometimes simultaneously widening of the superior part of the cervical canal with scalloping of the posterior arch of CI was seen.

# CONCLUSION

Exact localization of posterior fossa space occupying lesions depends largely on the successful filling of the fourth ventricle and cisterns; preferably this is done by lumbar pneumoencephalography.

In differentiating between the benign cerebellar astrocytoma and the malignant medulloblastoma including the so-called cerebellar sarcoma, it is necessary to search for skull changes caused by longstanding increased intracranial pressure.

The findings favoring a diagnosis of cerebellar astrocytoma are: enlargement of the occipital emissary vein opening, especially if it exceeds 4 mm.; widening of the entrance of the sella turcica; sellar destruction in patients over the age of 5 years and splitting of the sutures in patients over the age of 5 years. Those strongly favoring a diagnosis of benign lesions of long duration are: pronounced basi-occiput concavity and lateral displacement of the jugular tubercles. To arrive at a definitive diagnosis, it is necessary to correlate the findings on the routine roentgenograms of the skull with the air study.

The number of cases with so-called cerebellar sarcoma<sup>9</sup> was too small to justify the formation of a separate group. Their behavior is similar to that of the medullo-blastomas.

## SUMMARY

A review is given of 173 cases of posterior fossa space occupying lesions in infants and children.

The importance of the air study in localizing the lesion is demonstrated. An attempt is made to differentiate between the cerebellar astrocytomas and the rapidly growing malignant cerebellar medulloblastomas including the so-called cerebellar sarcomas.

Routine skull roentgenograms are of assistance in the differential diagnosis between benign and malignant posterior fossa tumors. The significant findings are suture splitting, sella turcica changes, enlargement of the occipital emissary vein opening and deformities of the basi-occiput.

Two basi-occiput deformities are described as new findings suggesting that a lesion is of long duration.

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We would like to express our debt to Dr. W. Krause from the Department of Pathology, the Hospital for Sick Children (Director of Pathology, Dr. W. L. Dono-

hue); now Associate Professor in the Sick Children's Hospital, Halifax, for reviewing the microscopic diagnosis.

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# MUSCLE GROUP SIGNS AND PUBIC VARUS AS A MANIFESTATION OF HIP DISEASE IN CHILDREN

By JOSEPH P. ARCOMANO, M.D., GENE STUNKLE, M.D., JAMES C. BARNETT, M.D., and JAY P. SACKLER, M.D.

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HEFKE and Turner,<sup>8</sup> in 1942, described roentgen changes involving the obturator internus muscle as a specific manifestation of an infectious arthritis at the hip joint. They referred to the relative increase in size of the obturator internus muscle on one side as compared to the other as the "obturator sign."

Drey,<sup>2</sup> in 1953, demonstrated that nonspecific inflammatory disease of the hip joint could affect any of the muscle groups in juxtaposition with the joint. These muscles include the obturator internus, gluteus medius (minimus), and iliopsoas. He also noted that in 9 of the 10 cases of transitory synovitis that he had observed, there was enlargement of the iliopsoas, which he referred to as the "iliopsoas sign."

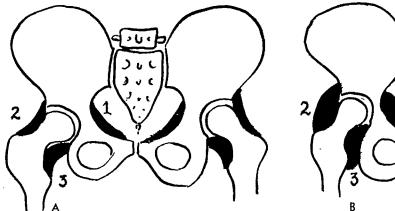
In a review of our own material at St. Charles Hospital, we have not been able to corroborate the high incidence of positive findings involving the muscle groups described in either specific infectious arthritis or in transitory synovitis (Table 1).

# ROENTGEN ANATOMY

- 1. The obturator internus muscle is seen as a muscle density beginning below the level of the greater sciatic notch, projecting inferiorly and paralleling the superior pubic ramus, ending in the region of the concavity of the lateral wall of the symphysis pubis (Fig. 14).
- 2. The gluteus medius (minimus) arises lateral and superior to the lateral acetabular angle and projects inferiorly to the level of the greater trochanter (Fig. 1A).
- 3. The iliopsoas is seen as a muscle density on roentgenograms of the hips arising below the inferior pubic ramus and projecting to the level of the lesser trochanter to which it attaches. It must be separated from the pectineus which inserts below the lesser trochanter and should not be confused with it (Fig. 1A).

# ROENTGEN TECHNIQUE AND FINDINGS

In almost all of our evaluations of hip disease in children, we have employed an



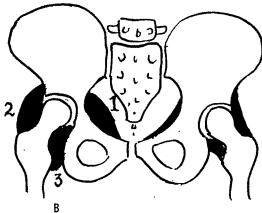


Fig. 1. (A) Normal muscle group findings. 1—Obturator internus; 2—gluteus medius (minimus); and 3—iliopsoas. (B) Abnormal muscle group findings on right manifested by enlargement of the muscle bundles described in A.

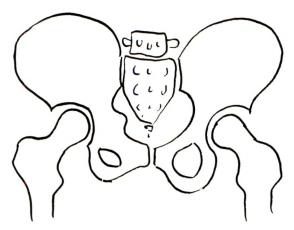


Fig. 2. Bony components of the right side of the pelvis demonstrating positive pubic or ischial varus (see text).

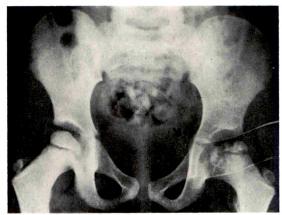


Fig. 4. Legg-Perthes' disease at the height of the degenerative stage demonstrating a positive obturator sign and pubic varus.

anteroposterior roentgenogram of the pelvis to include both hips, a "frog lateral" study, and a horizontal lateral study of both hips. In all of the cases that we have reviewed, we have selected roentgenograms in which the spinous processes of the lumbosacral spine and sacrum bisect the symphysis pubis, or in which the sacral neural foramina are symmetrically placed. It is important that these criteria be met in evaluating these signs since minimal pelvic rotation can produce an apparent change in the size of the muscle groups described and give either false positive or negative results.

The correlative work of Hefke and Turner<sup>3</sup> with cadaver specimens and roent-

genograms of the hip definitely established the obturator internus muscle as the muscle which was involved in their cases of infectious arthritis at the hip joint. Their work indicated that in the presence of infection, the intermuscular fatty septum separating the muscle bundles from surrounding soft tissues was either obliterated, as compared to the opposite normal side, or was displaced because of apparent enlargement (Fig. 1B). Drey<sup>2</sup> subsequently indicated that the gluteus medius (minimus) and iliopsoas muscle bundles could also be involved in the same fashion and included transitory synovitis as a nonspecific inflammatory disease which could produce this

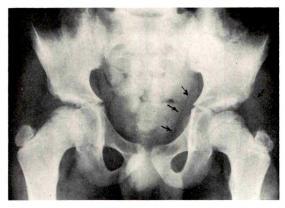


Fig. 3. Acute transient tenosynovitis with positive muscle group findings as indicated by arrows. Note pubic varus.



Fig. 5. Ewing's sarcoma. There is obliteration of the left obturator internus and pubic varus.

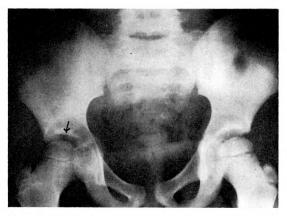


Fig. 6. Early tuberculosis of right acetabulum. Negative muscle group signs are noted. Pubic varus is present.



Fig. 7. Advanced destructive change in right hip secondary to tuberculosis. Note obliteration of all muscle groups and advanced pubic varus.

change. It has never been established whether the apparent enlargement of these muscle groups is due to secondary involvement by inflammatory change with resultant edema, or whether this is a reflective change in that the enlargement represents spasm and shortening of specific muscle bundles with resultant apparent enlargement. We are inclined to feel that the latter is more pertinent. We have noted changes involving the osseous components of the pelvis which we refer to as "pubic or ischial varus," and which, in our opinion, can only be a manifestation of the spasm and shortening phenomenon (Fig. 2).

Pubic or ischial varus, as we refer to it,

appears to be a manifestation of the same dynamic change which occurs in the spine when paravertebral muscle spasm is present. The syndesmotic and synchondritic joints of the pelvis in children allow the spastic muscle components of the affected side, by their process of shortening, to alter the relationship of the ischium to the ilium to produce a relative iliac flare and an apparent widening of the sacrosciatic notch. The axial rotation of the pubic bones as a result of the muscle group spasm produces a decrease in the vertical height of the entire affected pubic component of the pelvis with relative narrowing of the obturator foramen (Fig. 2).

 $T_{\rm ABLE~I}$  cases of hip diseases in children showing positive muscle signs or pubic varus

Disease or Condition	Total No. of Cases		Ischial	Positive Obturator Internus	Gluteus	Positive Iliopsoas
Legg-Perthes' Disease	70	35	33	24	3	5
Slipped Capital Femoral Epiphysis	30	0	0	0	0	0
Tuberculosis	3	2	2	I	0	0
Transitory Synovitis	27	6	5	2	0	0
Avascular Necrosis Due to:	,		5			
1. Unknown Etiology	2	I	I	I	0	0
2. Slipped Capital Femoral Epiphysis	I	I	I	I	0	0
3. Gaucher's Disease	I	I	I	0	0	0
Ewing's Sarcoma	I	I	I	I	0	0
Fibrosarcoma	I	0	0	0	0	0
Cysts of Proximal Femur	3	0	0	0	0	0

It has been our observation that the enlargement of a single muscle group, combination of muscle groups, the obliteration of the fatty septum between muscle groups, or the presence of pubic or ischial varus is not dependent on: (1) the specificity of the infection (tuberculosis versus other pyogenic infection); (2) the area of destructive bone change (acetabulum, pubic rami, or femur); (3) the nature of the chief complaint (hip versus knee pain); or (4) the clinical findings. In fact, in some cases of advanced destructive change of the bony components of the hip joint, we have found no reactive enlargement of the aforementioned muscles nor have we found obliteration of the soft tissue planes between these muscle groups.

It is obvious from Table I that a number of clinical conditions will produce the muscle group signs described, and more often pubic varus is also present. In Legg-Perthes' disease, specific infectious arthritis and trauma, the presence of pubic or ischial varus appears to be more common than the muscle group signs, and it has been our own experience that the muscle group signs have disappeared earlier in the disease than did the pubic varus. The latter, in most cases, seemed to follow the progress of the disease in its roentgen manifestations rather than the clinical course of the disease.

In many of the roentgenographic reproductions which have appeared in the literature, 1,2,3 illustrating the pathology of the hip joint, the presence of pubic or ischial

varus has been evident. We have, however, been unable to find specific reference to it, except in respect to Köhler's "tear drop," where asymmetry has been used as one of the many roentgen criteria of pathology about the hip joints in children.

#### SUMMARY

1. A review of our case material has alerted us to a roentgen sign in hip diseases in children which we have referred to as "pubic or ischial varus."

2. We have not found as high an incidence of positive muscle group signs as one might surmise from the previous literature

referring to these signs.

3. We have found that positive muscle group signs are not specific for any one disease at the hip and have observed them in the presence of tumor, infection, trauma, Legg-Perthes' disease and metabolic bone disease.

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# A NEW ROENTGEN FINDING IN PSEUDOHYPER-TROPHIC MUSCULAR DYSTROPHY\*

By HERBERT J. KAUFMANN, M.D. BASEL, SWITZERLAND

ROENTGEN changes affecting the skeleton in progressive muscular dystrophy have been described by several authors. 1–4,6 Girdany and Danowski² in a systematic roentgenologic survey of 31 patients came to the conclusion that "none of the changes save those in the soft tissues of the calves (in the pseudohypertrophic form) is pathognomonic for muscular dystrophy. Moreover with this exception all of the changes can be explained on the basis of prolonged disuse."

It is the purpose of this communication to present preliminary data on what is believed to be a specific roentgen finding in the pseudohypertrophic form of progressive muscular dystrophy.

# MATERIAL

In July of 1961, 3 brothers, aged 7, 10 and 12 years respectively, were hospitalized with this disorder at the Children's Hospital of the University of Basel. In all 3 the onset of the manifestations of the disease occurred between the ages of 2 and 3 years. In order to evaluate the degree of fatty degeneration and infiltration in the markedly hypertrophic muscle mass, lateral roentgenograms of both lower extremities were obtained. On all of the roentgenograms an unusual widening of the fibula in its anteroposterior diameter involving fourfifths of the diaphysis was demonstrated. In the 2 older brothers, the width at the widest diameter of the fibula equalled that of the tibia at its smallest diameter (Fig. 1, 2 and 3). Anteroposterior roentgenograms of the tibia and fibula were quite unremarkable.

These findings in 3 brothers affected with progressive muscular dystrophy brought to mind the following two questions:

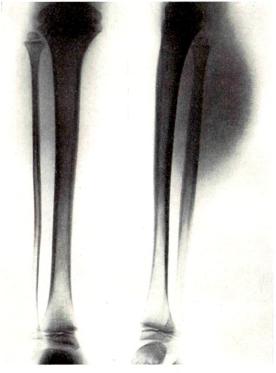


Fig. 1. B. R., 7 year old male with progressive muscular dystrophy. Anteroposterior and lateral roentgenograms of the right lower extremity show the typical increase in muscle mass of the calf (pseudohypertrophy) and widening of the anteroposterior diameter of the fibula.

- 1. Does this abnormality of the fibula represent a familial trait?
- 2. Are the changes of the fibula secondary to and the result of the underlying inherited disorder?

The anteroposterior and lateral roentgenograms of the lower extremities of all the rest of the members of this family (father, mother, I other son, and 5 daughters) were studied and in none were these same findings demonstrated. A search of our files and those of the Children's Hos-

<sup>\*</sup> From the Department of Radiology of the Children's Hospital of the University of Basel, Basel, Switzerland. Presented at the Annual Meeting of the Society for Pediatric Radiology, Washington, D. C., October 1, 1962.

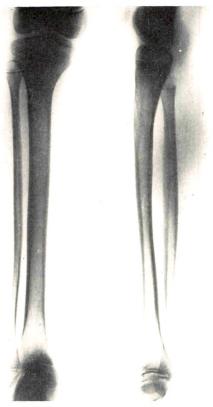


Fig. 2. B. K., 10 year old brother of patient shown in Figure 1 and also afflicted with progressive muscular dystrophy. Anteroposterior and lateral roentgenograms of the right lower extremity show a decided increase in the anteroposterior diameter of the fibula. Note the eccentric cortical thickening in the anterior aspect of the fibula with narrowing of the marrow cavity in its upper portion.

pital in Zürich\* disclosed 4 similar cases, all affected by the hypertrophic form of progressive muscular dystrophy. Two more patients similarly affected and presently followed in our out-patient department demonstrate the same fibular changes. A study of the roentgenograms of selected cases of other neuromuscular disorders affecting the lower extremities, *i.e.*, poliomyelitis (Fig. 4), meningomyelocele (Fig. 5), and transsection of the cord did not result in any similar findings; in fact, various degrees of virtually parallel atrophy of both tibia and fibula were noted.

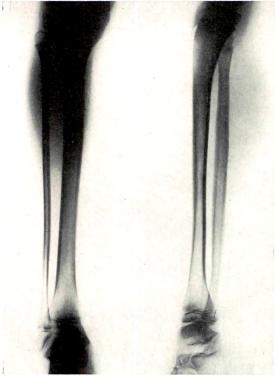


Fig. 3. B. A., 12 year old brother of patients shown in Figures 1 and 2. This patient, unlike his brothers, was bedridden for over 1 year. Similar changes of the fibula are demonstrated on the lateral roentgenogram.

# DISCUSSION

The ages of the 9 patients demonstrating the abnormal widening of the fibulae ranged from 7 to 17 years. The degree of widening in the anteroposterior diameter of the fibula differed somewhat. The ratio of the widest anteroposterior diameter of the fibula to the smallest anteroposterior diameter of the fibula to the smallest anteroposterior diameter of the tibia showed a range of 0.75–1.08 as compared to a rough estimate of the normal at 0.5–0.7. This value of normal is given for comparison. It was gained from a survey of 50 lateral roentgenograms of the lower extremity during childhood obtained for a multitude of disorders other than those of a neuromuscular origin.

Descriptively, a widened fibula is demonstrated with sclerosis of the middle two-thirds of its diaphysis and thickening of the corticalis to sometimes twice the normal size involving the anterior and upper por-

<sup>\*</sup> Courtesy of Dr. Giedion.



Fig. 4. P. R., 10 year old female who had been bedridden for 3 years because of severe totally crippling paralytic poliomyelitis. Anteroposterior and lateral roentgenograms of the right lower extremity show a normal width of the fibula in comparison with the tibia on the lateral roentgenogram. Marked cortical thinning and osteoporosis of all bones are also demonstrated.

tion with corresponding narrowing of the marrow cavity (Fig. 6 and 7). The thickness of the cortex of the fibula can be considerably greater than that of any cortical area of the tibia. However, in contrast to the widening in the middle section, the fibula, at both distal ends 2–3 cm. from the metaphyses, appears to be normal, thus presenting a disparity in the anteroposterior diameters of the affected fibula when comparing this area to the unusually widened middle section of the diaphysis. On the basis of these observations, it is felt that a new roentgen sign of the pseudo-hypertrophic form of progressive muscular

dystrophy has been noted. Its exact incidence, the time of onset of its development and its appearance during different stages of the basic disorder will have to be determined. The specificity of this finding must be confirmed.

The question of the mechanism leading to these changes cannot be answered as yet. That muscular forces would be instrumental appears most likely. If this were so, it might also be anticipated that in some patients with an unbalanced poliomyelitic paralysis similar changes could occur. A final point of interest beyond any specific or practical importance seems to be the theoretic implication of this finding with respect to extrinsic factors influencing the modeling of bones.<sup>5</sup>

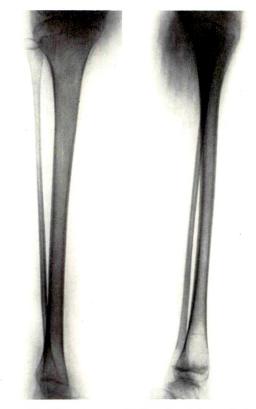


Fig. 5. W. M., 12 year old female with meningomyelocele and no use of lower extremities since birth. Both anteroposterior and lateral roentgenograms of the right lower extremity show thin bones. There is also slight cortical thinning and uniform osteoporosis.

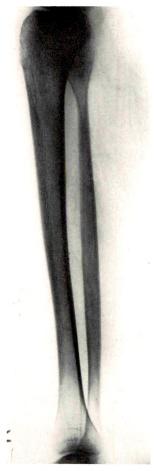


Fig. 6. L. W., 17 year old male with progressive muscular dystrophy. Lateral roentgenogram of the right lower extremity shows a definite increase in the anteroposterior diameter of the fibula, but there is no evidence of cortical thickening.

# SUMMARY

A preliminary report is presented on a new roentgen finding in the hypertrophic form of progressive muscular dystrophy. On roentgenograms of the lower extremities of 3 affected brothers, an unusual widening in the anteroposterior diameter of the middle two-thirds of the diaphysis of the fibula in the lateral view could be noted. A review of roentgenograms of other patients with muscular dystrophy revealed 6 further cases with this same striking picture. So far, all the patients presenting this sign had the pseudohypertrophic form of the disease.

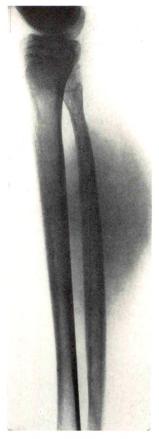


Fig. 7. D. R., 15 year old male with progressive muscular dystrophy. Lateral roentgenogram of the right lower extremity shows marked widening, sclerosis and cortical thickening of the fibula. Again the marrow cavity appears narrowed in its upper portion.

The increased anteroposterior diameter of the fibula is distinguished by a thickening of the cortex in its anterior and upper aspect, sometimes with narrowing of the medullary cavity. No changes of the fibula are visible in the anteroposterior view and the tibia appears to be entirely unaffected.

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# EARLY CLOSURE OF THE STERNAL SUTURES AND CONGENITAL HEART DISEASE\*

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THE medical literature contains numerous articles describing congenital and developmental abnormalities of the sternum. <sup>3,11,12,13,14,18,19</sup> Only recently has it been appreciated that early closure of the sternal sutures may have more than a casual relationship with congenital heart disease.

Our objective is to review the pertinent literature and to add 16 cases of early closure of the sternal sutures to the total of 21 previously reported.

# ANATOMY

The developmental anatomy of the sternum will be only briefly discussed, since it has been described in detail by several authors in the past.<sup>2,6,7,8,9,16,17</sup>

There are 3 major divisions of the sternum; namely, the manubrium, the mesosternum, and the xiphoid process. The manubrium and xiphoid process almost always arise from single, median ossification centers. The cartilaginous center in the xiphoid process may never become ossified.17 The development of the mesosternum is very variable. There are sometimes 3 but not infrequently as many as 8 ossification centers destined to form the 3 or 4 mesosternal segments. 16,17 Those mesosternal ossification centers which are symmetric and laterally located ordinarily fuse in the midline either before birth or during infancy. The mesosternal segments tend to fuse in a caudo-cephalad direction, as shown in Figure 1. Complete fusion of the mesosternum is said to be rarely found prior to the age of 16 years.7 Paterson17 has in a few cases seen younger sterna with all the mesosternal segments fused into a single bone. The youngest anatomic specimen was from an individual 12 years old. No clinical information regarding the cause of death in these cases is available.

The manubrium and mesosternum usually remain unfused to each other throughout life, but synostosis of these bones is reported to occur in about 10 per cent of supposedly normal adults.<sup>2,7,17</sup> Likewise, the mesosternum fuses with the xiphoid process in about 30 per cent of individuals after the second decade.<sup>7,17</sup>

Sixteen cases of early closure of the sternal sutures have been seen by us. A brief report of the cases is presented.

## REPORT OF CASES

The following 7 cases showed complete fusion of the entire sternum, including obliteration of the manubriosternal joint.

Case I. This female at the age of 17 years was admitted to the hospital with a diagnosis of cyanotic congenital heart disease. Cardiac catheterization and angiocardiography revealed an interventricular septal defect and pulmonary hypertension. A lateral roentgenogram of the sternum showed obliteration of the sternal sutures as well as pronounced anterior bowing of the sternum (Fig. 2). No information regarding the sterna of the parents is available.

Case II. A 20 year old white male had frontal and lateral chest roentgenograms made when he was hospitalized for recurrent folliculitis of the scalp of 2 years' duration. Early closure of the sternal sutures and marked bowing of the sternum were noted (Fig. 3). There was no evidence of congenital heart disease or other congenital malformations either by history or

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<sup>\*</sup> This material has been reviewed by the Office of The Surgeon General, Department of the Army, and there is no objection to its presentation and/or publication. This review does not imply any endorsement of the opinions advanced or any recommendation of such products as may be named.

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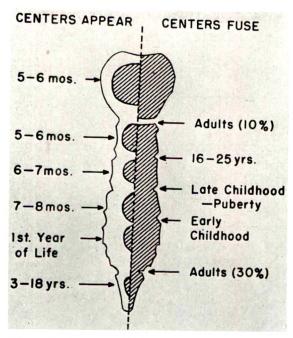


Fig. 1. Ossification and fusion of the various sternebrae (infant and adult sternum). (Reproduced by permission of *Radiology*.<sup>7</sup>)

physical examination. The parents were not available for examination of their sterna.

Case III. This 4 year old white female had two cardiac catheterizations in 1959, when an ostium primum type atrial septal defect and pulmonic valve stenosis were diagnosed. Pulmonary hypertension and pulmonic valve insufficiency developed during the next 2 years, confirmed by repeat catheterization, angiocardiography, and at surgery in 1962, when the atrial septal defect was repaired. The reason for the pulmonic valve insufficiency is not known. Numerous blood cultures have been negative.

The lateral roentgenograms of the sternum showed the typical appearance of early closure of the sutures (Fig. 4 and 5). Nothing is known about the appearance of the parents' sterna.

Case IV. This 4 year old white boy has had a heart murmur since the age of I year. There was no history of cyanosis, dyspnea, or growth failure. A diagnosis of interventricular septal defect was established by cardiac catheterization. A lateral roentgenogram of the sternum showed early closure of the sternal sutures. It is not known whether the manubriosternal joint is fused in the sterna of the parents.

Case v. This white male was cyanotic since birth and died at the age of 7 months. Autopsy revealed partial transposition of the great vessels, pulmonic valve stenosis, atrioventricularis communis, patent ductus arteriosus, and thrombosis of the superior sagittal dural sinus. A lateral roentgenogram of the sternum showed early closure of the sternal sutures. The manubriosternal joint of the father was found to be open. The status of the sternal sutures in the mother is unknown.

Case VI. This 4 year old male of Latin American descent developed normally. There was no evidence of cyanosis or clubbing. A Grade II systolic murmur was heard to best advantage half way up the right sternal border. The murmur was considered functional by the cardiologist. Frontal roentgenograms of the chest demonstrated dextrocardia but no complete situs inversus. The aortic arch was on the left side. An electrocardiogram was interpreted as compatible with dextrocardia without chamber inversion.

A lateral roentgenogram of the sternum showed the typical findings of early closure of the sternal sutures. The sterna of the parents have not been examined roentgenographically.

Case VII. At the age of 3 years, this white

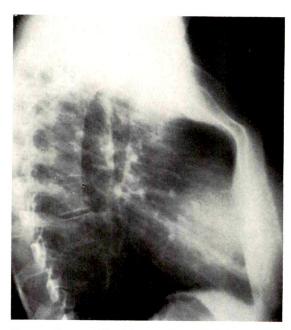


Fig. 2. Case i. All of the sternal sutures are obliterated. There is pronounced anterior bowing of the sternum.

female had a Blalock operation for tetralogy of Fallot. She is currently 16 years old and doing well. Only one episode of definite cyanosis occurred recently. A lateral roentgenogram made at the age of 12 showed that the sternal sutures were either closed or almost closed. No information regarding the sterna of the parents is available.

The next 6 cases also demonstrated early closure of the sternal sutures, although the manubriosternal joint was not completely fused.

Case VIII. At the time when this 4 year old boy of Latin American descent had an upper respiratory tract infection, a routine physical examination revealed a Grade II systolic murmur. It was heard best along the left sternal border in the third intercostal space. The chest

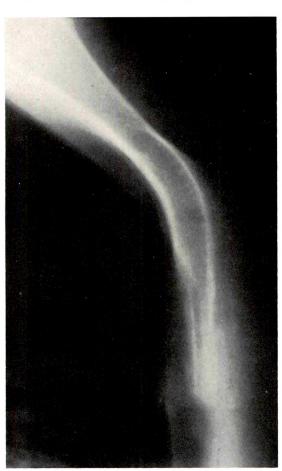


Fig. 3. Case II. Characteristic appearance of early closure of sternal sutures, with marked anterior bowing of the sternum.

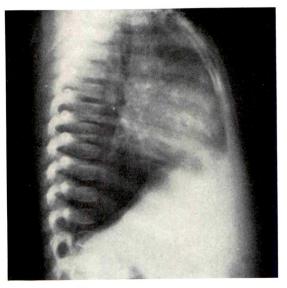


Fig. 4. Case III. Appearance of sternum at 3 weeks of age.

wall was asymmetric. The electrocardiogram was normal. The clinical impression was that the heart murmur was functional. Cardiac catheterization and angiocardiography had not been performed.

A lateral roentgenogram of the sternum showed partial fusion of the manubriosternal joint. The mother, who is 29 years old, has an almost completely fused manubriosternal joint. The sternum of the father has not been examined for this abnormality.

Case IX. This 5 year old white female had a history of cyanosis only on crying. There was a coarse systolic murmur along the left sternal border, followed by an early, crescendo, diastolic rumble. The electrocardiogram was interpreted as showing right atrial dilatation and incomplete bundle branch block. Roentgenograms of the heart with barium in the esophagus revealed cardiac enlargement, believed to be mainly due to right atrial and right ventricular prominence. A lateral roentgenogram of the sternum showed a partially closed manubriosternal joint. Cardiac catheterization was consistent with the clinical diagnosis of Ebstein's disease.

The mother is currently 43 years old and has a normal sternum. There are no lateral roent-genograms of the father's chest available.

Case x. This 4 year old female had congenital absence of the right external auditory canal and

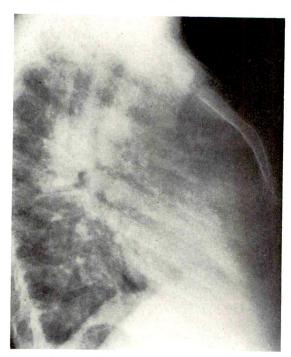


Fig. 5. Case III. Lateral roentgenogram of the sternum at  $4\frac{1}{2}$  years of age. All of the mesosternal segments and manubrium are now fused into a single bone.

auricle, hypoplasia of the right side of the mandible, and a supernumerary right thumb removed. An early, Grade I systolic murmur was best heard in the anterior fourth intercostal space but disappeared in the upright position. An electrocardiogram revealed left axis deviation and retrograde atrial depolarization. The cardiologist believed that the murmur in this child was functional and did not feel that congenital heart disease was present. However, the abnormal electrocardiographic findings remain unexplained.

A lateral roentgenogram of the sternum showed fusing of the manubriosternal joint (Fig. 6). No information regarding the sterna of the parents is available.

Case XI. This 4 year old male had a history of questionable birth trauma. He had never been cyanotic. On examination, he was noted to be retarded mentally and understood only simple commands. His language was limited to "mama" and "papa." The short frenulum of the tongue was not thought to interfere with his ability to speak. He was also believed to have marked congenital loss of hearing. There was a midsystolic murmur along the left sternal bor-

der. The electrocardiogram showed right ventricular hypertrophy. No cardiac catheterization or angiocardiography had been performed. The clinical impression was that this patient probably had congenital heart disease of undetermined type.

A lateral roentgenogram of the sternum showed a narrow, closing manubriosternal joint. The mother, who is 38 years old, was found to have an open manubriosternal joint. No chest roentgenograms of the father are available.

Case XII. A 5 year old white female had been found to have a heart murmur. Further studies led to a diagnosis of patent ductus arteriosus, which was ligated surgically. The patient is doing well. The lateral roentgenogram of the sternum showed the characteristic findings of fusion (Fig. 7). The status of the sterna of the parents is not known.

Case XIII. A heart murmur had been noted in this asymptomatic white male at the age of 6 years. He had been told that the murmur most likely would disappear. Physical examination at 19 years of age revealed a machinery-like murmur in the left second anterior intercostal space. A patent ductus arteriosus was ligated and divided surgically. The patient is doing well.

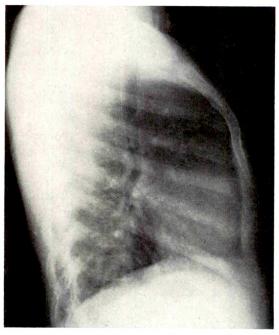


Fig. 6. Case x. The manubriosternal joint is in the process of fusing.

A lateral, preoperative roentgenogram showed almost complete fusion of the manubriosternal joint. The parents have not been available for examination.

Two patients demonstrated progressive closure of the mesosternal sutures. The authors believe that these cases are less pronounced examples of early closure of the sternal sutures.

Case XIV. History revealed that this 8 year old female of Latin American descent had a heart murmur since birth. She had been hospitalized a number of times for respiratory tract infections. Cardiac catheterization and angiocardiography in 1961 disclosed a patent ductus arteriosus, which was ligated soon afterwards. The patient has done well since. Lateral roentgenograms of the sternum showed progressive closure of the mesosternal sutures (Fig. 8 and 9). The sterna of the parents have not been examined for fusion at the manubriosternal joint.

Case xv. This 9 year old female of Latin American descent developed cyanosis at 5

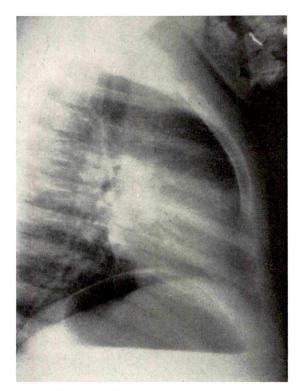


Fig. 7. Case XII. The manubriosternal joint shows signs of impending fusion.

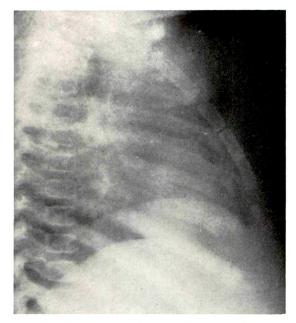


Fig. 8. Case xiv. Appearance of sternum at 1 year of age.

months of age. On the basis of cardiac catheterization data and angiocardiography, the patient was thought to have cor triloculare biatrium, an interatrial septal defect, and a right sided aortic arch. Lateral roentgenograms of the sternum at the age of 4 years demonstrated the joint between the first and second mesosternal joints to be open. At the age of 8 years the latter joint had fused and the mesosternum has subsequently appeared as a single, solid, nonsegmented bone. The sterna of the parents are normal.

Case xv is unusual in that there appears to be complete fusion at the manubriosternal joint, while the mesosternal sutures are still open.

CASE XVI. The mother of this 6 year old white male had had German measles at approximately 3 weeks' gestation. The patient was deaf since birth and had congenital cataracts in addition to tetralogy of Fallot, the last diagnosis being confirmed by cardiac catheterization and angiocardiography. A lateral roentgenogram of the sternum showed almost complete fusion of the two vertically placed manubrial ossification centers as well as obliteration of the manubriosternal joint (Fig. 10). The status of the sterna of the parents is not known.

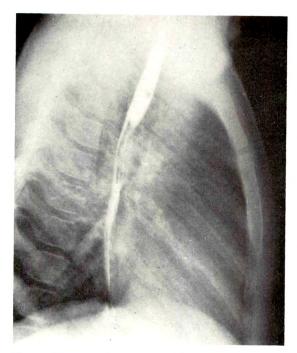


Fig. 9. Case xiv. Appearance of sternum at 5 years of age. All of the mesosternal sutures are completely obliterated.

#### DISCUSSION AND REVIEW OF LITERATURE

Paterson<sup>16,17</sup> found in a study of 236 fetal sterna that the junction between manubrium and mesosternum was fibrous in 76.4 per cent and cartilaginous in 23.6 per cent. The latter type makes it possible for fusion to take place between the manubrium and mesosternum.2 Ashley2 states that he would go further and assert that in something under 20 per cent of all individuals synostosis of the manubriosternal joint will inevitably occur in early adulthood because of the failure of development during fetal life of the fibrous lamina between manubrium and mesosternum. He refers to two types of fusion at the manubriosternal joint. The primary or "matrical" type of synostosis develops rather early in life from obliteration of a primary cartilaginous joint between manubrium and mesosternum and is presumably inevitable. The secondary or "sclerotic" synostosis results from obliteration of a secondary cartilaginous joint between the manubrium and the mesosternum. This last type occurs during late

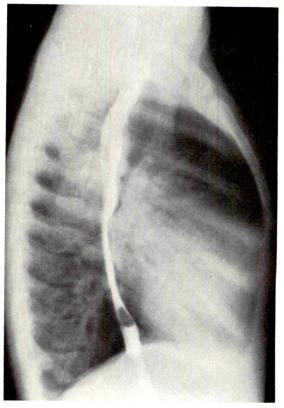


Fig. 10. Case xvi. There appears to be almost complete fusion of two vertically placed manubrial ossification centers, such as may occur normally. In addition, the manubriosternal joint is believed to be obliterated, with only a faint increase in density remaining along the closed joint at the level of the second costal cartilages. The mesosternal sutures are still open.

adult life and is thought to be due to various pathologic processes.

Ashley also felt that the relative infrequency of the matrical type of synostosis in the aged suggests that individuals whose sterna show this type of synostosis tend to die before reaching old age. His obvious conclusion was that, either the illness from which the individual suffered caused synostosis of the manubriosternal joint, or that an existing synostosis of the manubriosternal joint was a factor predisposing to contraction of the specific illness which led to death. He recommended that appropriate studies with clinicopathologic correlation should be undertaken.

The authors of the present article would

 $T_{\rm ABLE~I}$  summary of previously reported cases of early closure of sternal sutures

Author	Year	Case No.	Sex	Age	Associated Congenital Abnormalities	briosteri	Manu- nal Joint arents
II 1 0					N. information	Father	Mother
Herdner <sup>9</sup> Monnet <i>et al</i> . <sup>15</sup>	1947 1956	I	;	7 yr. 5 mo.	No information Transposition of great vessels; partial anomalous pulmonary venous drainage; interventricular septal defect	?	?
Currarino and Sil- man <sup>7*</sup>	1958	I	M	4 yr.	Micrognathia; bilateral clubfoot; inguinal hernia; cryptorchidism	-	+
		2	F	ı yr.	Physical retardation; asymmetry of head, face and eyes; microphthalmia and cata- ract of left eye; pigmented skin lesions; aberrant right subclavian artery	+	_
		3	Μ	13 yr.	Patent ductus arteriosus; interventricular septal defect	_	?
		4	F	3 da.	Atresia of esophagus; tracheoesophageal fistula	;	;
		5	$\mathbf{M}$	4 mo.	Congenital laryngeal stridor	_	+
		6	F	8 mo.	Micrognathia; large ears; beaked nose	_	$\pm$
		7	F	8 mo.	Twin of Case 6; same abnormalities plus pat- ent ductus arteriosus	_	$\pm$
		8	F	17 yr.	Physical and mental retardation; defective dentition; high, arched palate; hypotelor- ism; prognathism; patent ductus arteriosus	;	?
		9	M	13 yr.	Interventricular septal defect; pulmonary arterial hypertension; cyanosis	?	;
		IO	$\mathbf{M}$	II yr.	"Idiopathic" scoliosis	?	+
Andrén and Hall¹	1961	I	F	15 yr.	Interatrial and interventricular septal defect	s ?	;
		2	$\mathbf{M}$	14 yr.	Tetralogy of Fallot	?	?
		3	M	6 yr.	Interatrial septal defect; pulmonic valve stenosis	5	j
		4	М	10 yr.	Syndactylia, left hand; possible congenital heart disease	5	}
		5	$\mathbf{M}$	36 yr.	Pulmonic valve stenosis	?	5
		5 6	M	3 wk.	Aortic valve atresia; hypoplastic left ven- tricle; patent ductus arteriosus; super- numerary phalanges of both thumbs	?	?
		7	F	14 yr.	Left ventricular hypertrophy; vascular abnormality of renal arteries	5	5
Brünner <sup>4</sup>	1961	I	$\mathbf{M}$	7 yr.	Tetralogy of Fallot; patent ductus arteriosus	?	?
Kjellberg et al. <sup>10</sup>	1961	I	F	9 yr.	Patent foramen ovale; pulmonic valve stenosi		;
Total		21 Ca	ases				

<sup>\*</sup> Reference to 1 of the cases is made by Caffey.5

also like to advance the possibility that perhaps some type of injury to the developing fetus at times may produce both early closure of the sternal sutures and congenital heart disease. The latter certainly is an important cause of death in children and young adults. It should be mentioned in this regard that the first anlage of the ster-

num can be recognized in the 6 week old human fetus. 8 On the other hand, we realize that segmentation of the sternum and subsequent fusion of the sternebrae can be observed only at considerably more advanced stages of development. 8,16,17

Hanson<sup>8</sup> has suggested that the pattern of strain exerted by the ribs on the sternum probably is responsible for its particular mode of segmentation. Paterson<sup>17</sup> considered it possible that mechanical forces due to attachment of the sternum to the costal cartilages and factors related to the expansion of the thorax and its visceral structures might initiate ossification in the cartilaginous centers of the sternum. Similarly, we wonder whether obliteration of the sternal sutures may be accelerated by abnormal size or position of the heart in congenital heart disease.

Of interest was the finding of a closed or nearly closed manubriosternal joint in at least I of the parents of 6 of the 10 children who showed premature obliteration of the sternal sutures as reported by Currarino and Silverman. They commented on the possible genetic implications and also pointed out that early closure of the sternal sutures may produce a characteristic pigeon-breast or pectus carinatum deformity.

In Table 1 a summary is given of the previously reported cases of early closure or premature synostosis of the sternal sutures. The case referred to by Herdner<sup>9</sup> was found in an anatomic and not a clinical study. It is interesting to note that in all of the remaining cases, the sternal abnormality was not an isolated finding. As shown in Table 1, 16 cases had associated congenital cardiovascular abnormalities. The remaining 4 also had various other congenital malformations.

These tendencies are confirmed in our own case material, as at least 13 of our 16 cases of early closure of the sternal sutures are believed to have associated congenital heart disease, and I additional case has other congenital abnormalities.

One case in the series by Currarino and Silverman<sup>7</sup> and the case presented by Brün-

ner<sup>4</sup> demonstrated the progressive, early fusion of the sternal sutures with evidence that the abnormality is not a question of nonsegmentation or failure of original segmentation but rather early closure or premature synostosis. Additional support for this opinion is supplied by Cases III, XIV and XV in our own series. However, it is quite possible that failure of original segmentation may also occur.

Paterson<sup>16,17</sup> states that the fibrous septum at the manubriosternal joint very consistently is located at the level of the second costal cartilages, but he has on one occasion found this joint at the level of the third costal cartilages. Case xvi in our series may be such an example in a patient with congenital heart disease; however, the authors believe that this perhaps represents premature closure of the manubriosternal joint (Fig. 10). This occurrence would be contrary to the usual progression of fusion in a caudo-cephalad direction. Our findings in Case xvI may also be similar to those in 5 sterna from considerably older individuals in Paterson's anatomic study. In these specimens the first segment of the mesosternum was separated from the remaining mesosternal portion but fused to the manubrium.17 The exact significance of such an arrangement is not clear. It would have been interesting to have clinicopathologic correlation in these 5 cases. Congenital heart disease could possibly be responsible in our case. Further investigation is obviously indicated.

#### SUMMARY AND CONCLUSIONS

- 1. The literature of cases with early closure of the sternal sutures has been reviewed.
- 2. Sixteen additional cases of early closure of the sternal sutures have been presented.
- 3. This condition is usually associated with other congenital abnormalities, particularly congenital cardiovascular disease.
- 4. The etiology of early closure of the sternal sutures is unknown. Some possible causes have been discussed.

- 5. Early closure of the sternal sutures may produce bowing of the sternum or a pectus carinatum deformity.
- 6. The finding of early closure of the sternal sutures should alert the radiologist to the possibility of other associated congenital malformations, of which the most important group is congenital heart disease.

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### CONGENITAL LEVOPOSITION OF THE RIGHT ATRIAL APPENDAGE\*

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CONGENITAL levoposition of the right atrial appendage is a rare cardiac malformation in which the right atrial appendage protrudes to the left behind the origins of the great vessels, instead of being in the normal position to the right and ventrad to the proximal ascending aorta. In this anomaly the typically enlarged right atrial appendage constitutes part of the left upper border of the cardiac silhouette in the conventional region of the main pulmonary artery. The anomaly is always part of a complex cardiac malformation invariably including some type of transposition of the great vessels.

Clear demonstration of levoposition of the right atrial appendage by angiocardiography has not previously been presented in the literature. Consequently the following case is reported and the condition briefly reviewed.

#### REPORT OF A CASE

B.S. 1399239. This full term white male infant was noted to be cyanotic and to have a heart murmur a few hours following a normal delivery. The pregnancy had been uneventful, and no history of congenital heart disease in the family could be elicited. The infant developed normally during his first 2 years despite moderately severe cyanosis which was increased with exercise. After his first syncopal episode at 2 years of age he was admitted for study.

Physical examination revealed a well developed and well nourished, markedly cyanotic child. The blood pressure was 100/60. Moderate digital clubbing was present. A harsh grade IV systolic murmur was loudest in the left fourth intercostal space at the left sternal border. No diastolic murmur was heard and peripheral pulses were normal. P2 was loud and single.

Roentgen examination revealed moderate cardiac enlargement with a peculiar flattening of the lower right heart border and clear lung fields (Fig. 1, A and B). Electrocardiograms were interpreted as indicating right atrial and right ventricular enlargement with an unusual right superior QRS axis in the frontal plane.

Selective right and left atrial angiocardiography clearly demonstrated levoposition of the right atrial appendage, transposition of the great vessels, large ventricular septal defect with bidirectional shunts, possible tricuspid stenosis, small right to left interatrial shunt, patent ductus arteriosus and pulmonary stenosis with hypoplastic main and left pulmonary arteries and large right pulmonary artery (Fig. 2–4, inclusive).

On July 14, 1961 an anastomosis of the end of the left subclavian artery to the side of the left pulmonary artery was made. At operation much bronchial collateral circulation was noted. Postoperatively, cyanosis diminished and substantial clinical improvement has resulted.

#### DISCUSSION

Dr. Dorothy H. Andersen of the Department of Pathology at Babies Hospital has encountered 5 additional examples of this malformation among about 500 major cardiovascular anomalies found at necropsy in children up to 12 years of age. All of these cases died before reaching the age of 6 months. In each some form of transposition of the great vessels was found.

Smyth<sup>8</sup> in 1955 summarized the data on the 16 cases of this anomaly reported up to that time. Since then 2 other reports have appeared<sup>3,9</sup> though undoubtedly a number of other cases have been included in articles not dealing exclusively with this subject. Of this total experience of 24 cases, all have been associated with some form of transposition of the great vessels. About

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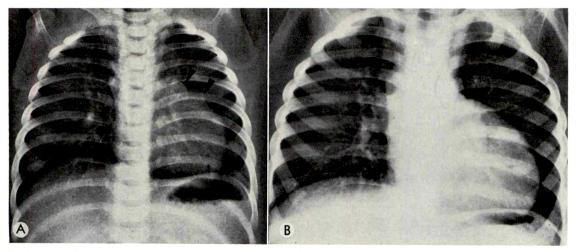


Fig. 1. (A) Chest roentgenogram at 6 months of age demonstrates a heart which is mildly enlarged and prominent on the left with two convexities (arrows) along the left upper heart border probably representing lateral margins of the right (more cephalad) and left atrial appendages. (B) At 2 years of age the heart is relatively larger projecting mainly to the left. Note the flat inconspicuous margin of the right atrium along the lower right heart border.

half of the cases have had pulmonary stenosis, 7 have had tricuspid atresia, and a wide variety of other malformations have also been encountered.

Clinically, cases with this anomaly are usually recognized in infancy as having severe cyanotic congenital heart disease. The clinical features have been dependent upon the particular complex of additional cardiac anomalies present.

Insufficient leftward migration of the truncus permitting the right atrial appendage to develop on the left side of the great vessels has been considered the major factor in embryonic pathogenesis.<sup>1,8</sup> Correspondingly, in the 2 reported cases with both atrial appendages on the right side of the great vessels—congenital dextroposition of the left atrial appendage<sup>8</sup>—inversion of the bulboventricular loop was pres-

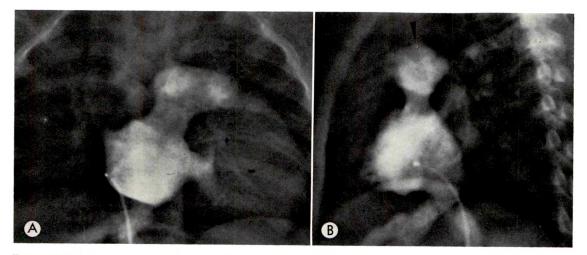
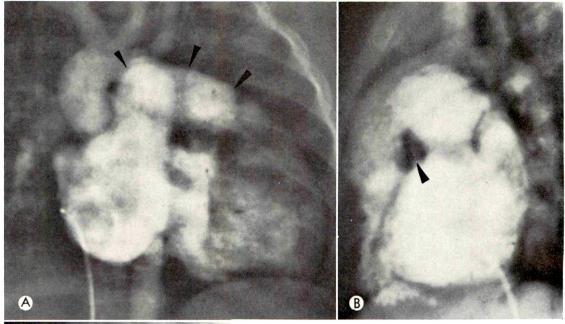


Fig. 2. (A) Selective angiocardiogram showing right atrial opacification and large right atrial appendage extending cephalad and to the left of midline. (B) Simultaneous lateral projection showing opacified right atrium and large atrial appendage (arrow). Contrast material has partially opacified the left atrium via atrial septal defect.



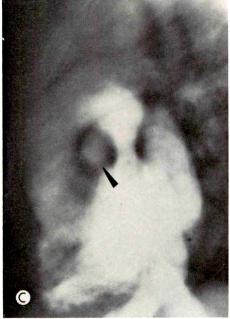


Fig. 3. (A) Frontal angiocardiogram made 0.7 seconds after Figure 2 shows that all cardiac chambers have opacified and a large aorta ascends on the right and arches to the left. Note huge right atrial appendage (arrows). (B) Simultaneous lateral view demonstrates transposition of the great vessels with ventrad origin of the aorta from right ventricle and posterior origin of narrow main pulmonary artery (arrow) immediately ventrad to right atrial appendage. (C) With right atrial appendage contracted in systole, note the increase in the size of the proximal main pulmonary artery (arrow).

ent. The universal presence of some type of transposition of the great vessels together with other anomalies implies that levoposition of the right atrial appendage occurs only as part of a complex aberration in cardiac development.

No generally accepted name for this anomaly has evolved. Smyth<sup>8</sup> has suggested "lateroposition of the atrial ap-

pendages" modified by the terms "levo" or "dextro"—as the case may be. He details the history of other terms such as "juxtaposition of the atrial appendages," "transposition of the two auricular appendages" or "sinistroposition of the right auricle" which have been applied to the anomaly. We prefer the term—congenital levoposition of the right atrial appendage.

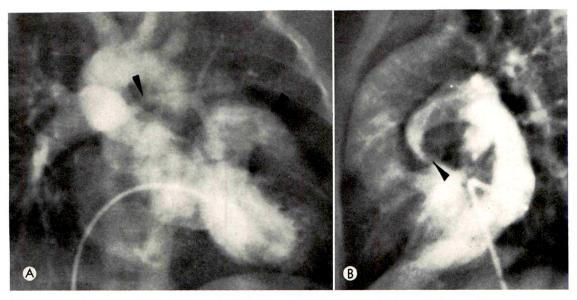


Fig. 4. (A) Selective angiocardiogram after injection of contrast material into the left atrium demonstrates in frontal projection opacification of the left atrium and ventricle. Note the position of the left atrial appendage (left arrow). The main pulmonary artery is obscured by opacification of the transposed aorta by way of large ventricular septal defect with a left to right ventricular shunt. The right pulmonary artery has a large caliber but the proximal main pulmonary artery and the left pulmonary artery (arrow) are small. A small patent ductus connects the left pulmonary artery to the aorta. (B) Simultaneous lateral projection shows narrow ascending pulmonary artery (arrow) arising dorsal to the large transposed aorta. The pulmonary artery is narrowest near its origin where it is adjacent to the nonopacified region occupied by the neck of the right atrial appendage.

#### ROENTGENOGRAPHIC FINDINGS

Frontal chest roentgenograms have been published of g cases. Six of these, despite the presence of cardiomegaly, had unusually flat, inconspicuous contours to the lower right mediastinal border, resembling those in Figure 1B in this respect, while the remaining 3 had dextrocardia.3,6,10 Four of the former cases had complicating tricuspid atresia,4,5,7,9 and the other 2 had hypoplastic right ventricles.1,2 Similar findings were present in 2 of the 3 Babies Hospital cases with available chest roentgenograms. One of these infants had associated tricuspid atresia while the other infant had a large right ventricle. The usually prominent upper right mediastinal border in these cases is a result of the prominent transposed ascending aorta.

A flat, inconspicuous right heart border is described by Taussig<sup>10</sup> as characteristic of tricuspid atresia, though it is found in only a fraction of the cases.<sup>11</sup> This config-

uration is particularly striking in those cases with both tricuspid atresia and levoposition of the right atrial appendage, although an exceptionally flat right heart border may be seen in either condition alone.

The angiocardiographic findings presented in Figures 2 through 4 clearly demonstrate the levopositioned right atrial appendage as it protrudes to the left behind the transposed great vessels. Figure 3, B and C demonstrates that, when the right atrial appendage is contracted in systole, the adjacent main pulmonary artery is maximally distended, while, when the appendage is distended in diastole, the main pulmonary artery is markedly narrowed as though compressed between the atrial appendage behind and the aorta in front. Since the pressure in the main pulmonary artery was very low, the small size of the proximal main pulmonary artery and its left branch may be related

to local extrinsic pressure by the abnormal appendage.

The position of the abnormally placed right atrial appendage as shown in Figure 2, A and B makes it obvious that this structure could easily be mistaken for the pulmonary artery—especially on venous angiocardiograms.

#### SUMMARY

Congenital levoposition of the right atrial appendage, a rare anomaly in which the right atrial appendage protrudes behind the great vessels to reach the left upper heart border, is clearly demonstrated angiocardiographically for the first time.

This malformation has been invariably associated with transposition of the great vessels together with a variety of additional cardiac anomalies. A relatively inconspicuous flat right lower heart border on frontal chest roentgenograms, in the presence of cardiomegaly and clinical cyanosis in individuals, especially infants with obviously serious congenital heart disease, should raise the possibility of this condition. Knowledge of the anomaly is of special importance to the proper interpretation of angiocardiograms in certain cases of transposition of the great vessels.

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# THE LEFT AORTIC DIVERTICULUM AS A COMPONENT OF A CONSTRICTING VASCULAR RING\*

#### REPORT OF TWO NEONATAL CASES

By PAUL C. WHEELER, M.D.,† and THEODORE E. KEATS, M.D.‡ COLUMBIA, MISSOURI

TRACHEO-ESOPHAGEAL compression due to vascular rings is now diagnosed and surgically corrected with increasing frequency because of the awareness of the clinical and roentgenographic manifestations of this condition. The varieties of these anomalies are multiple, and most have been thoroughly described in the literature.<sup>3,6,13</sup>

We have recently had experience with 2 patients in whom tracheo-esophageal compression resulted from a triad of abnormal vessels consisting of a right-sided aortic arch, left aortic diverticulum (remnant of the partially obliterated left aortic arch) and ligamentum arteriosum.

The purpose of this paper is to emphasize the aortic diverticulum as an active component of a constricting vascular ring. This structure is an important diagnostic clue.

#### REPORT OF CASES

Case I. K.H. (this case has been reported in detail elsewhere<sup>6</sup>), a 7 week old male infant, was admitted to the University of Missouri Medical Center because of rapid respirations and cough which appeared approximately 3 weeks after birth. On admission, mild cyanosis and dyspnea were present with crying. Blood pressures were normal. No cardiomegaly was noted, although a Grade 3/6 harsh systolic murmur was audible at the lower left sternal border.

Routine chest roentgenograms suggested right ventricular hypertrophy (confirmed by electrocardiograms), left atrial enlargement and pulmonary hypervascularity.

Esophagrams revealed an oblique extrinsic pressure defect of the upper esophagus, extend-

ing superiorly to the left (Fig. 1). This was thought to represent an anomalous left subclavian artery arising from a right-sided aorta. There was also pronounced posterior compression near the level of T-4 (Fig. 2). Tracheograms showed an indentation on the right just above the carina (Fig. 3).

Retrograde aortograms showed the presence of a right aortic arch in addition to a right descending aorta (Fig. 4). The trachea was crossed by an anomalous left common carotid artery anteriorly. The left subclavian artery was seen to arise from a diverticulum of the distal arch with a coarcted segment at its origin.

Thoracotomy revealed a vascular ring formed by a ligamentum arteriosum extending from a large diverticulum behind the esophagus, around the left side of the esophagus and trachea, and inserting into the pulmonary artery (Fig. 5, A and B). The left subclavian artery was coarcted at its origin from the diverticulum. In order to relieve the compression, the ligamentum arteriosum and left subclavian were transected, visibly releasing both constricting rings.

Sudden respiratory distress following surgery was not relieved by a tracheostomy, and the infant became progressively moribund and expired several hours later. Postmortem examination revealed a ventricular septal defect, right-sided aortic arch, transected ligamentum arteriosum and left subclavian, and an anomalous left common carotid artery. The left posterolateral esophagus was sharply indented by the left aortic remnant.

Case II. K.V., a term white male infant, was born at the University of Missouri Medical Center on August 31, 1961. The delivery was uncomplicated; the initial physical examination was negative. On the day following delivery,

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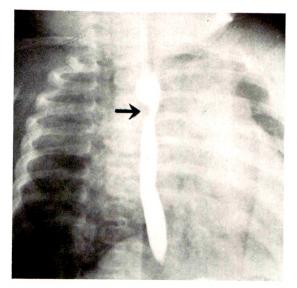


Fig. 1. Case 1. Oblique esophageal defect caused by anomalous left subclavian artery and right aortic arch.

scattered rhonchi were heard in both lungs, but he was otherwise well. By the third day, slight dyspnea was noted during feeding, followed by a transient increase in the rhonchi. A roentgenogram of the chest was not remarkable. A tracheo-esophageal fistula was suspected at this time, and an appropriate work-up was initiated.

On September 6, 1961, an esophagram showed bilateral compression of the esophagus at the level of the aortic arch in addition to a posterior indentation (Fig. 6, A and B). Moderate bilateral and anterior compression of the trachea was also demonstrated on a subsequent tracheogram. These findings were interpreted as representing a double aortic arch (with the major component on the right), forming a vascular ring about the esophagus and trachea.

The infant continued to have moderate respiratory difficulty during feedings and hyperextended his neck to facilitate breathing. On September 19, 1961, serialographic retrograde aortography was performed. Roentgenograms of the opacified proximal aorta (Fig. 7, A and B) showed a right aortic arch and right descending aorta. The left common carotid and left subclavian arteries arose slightly anterior to the normal position on the arch and crossed anteriorly to the trachea. An outpouching on the left lateral aspect of the proximal aortic arch was visualized and was felt to represent the remnant of the obliterated left aortic arch (aortic diverticulum). It was suggested that a

ligamentum arteriosum probably completed the constricting ring.

On the fortieth day, surgical exploration confirmed the presence of the aortic diverticulum on the descending portion of the right arch, from which a tight fibrous band extended around the left side of the esophagus and trachea and inserted into the pulmonary artery. In addition, 3 thin solid cord-like structures were found to extend from the diverticulum upward to the left subclavian artery as it passed anterior to the trachea (Fig. 8,  $\mathcal{A}$  and  $\mathcal{B}$ ). Transection of the tight ligamentum and these 3 bands resulted in immediate release of the constricting pressure on the trachea and esophagus.

The postoperative course was benign. At the time of discharge from the hospital 10 days later, some abnormal rattling in the chest was still noticeable after feeding, but the infant no longer hyperextended his neck and his respirations were much easier.

Follow-up esophagrams 2 months later (Fig. 9) showed a moderate persistence of the posterior esophageal compression by the diverticulum. Except for occasional mild upper respiratory infections, the child has remained well and is nearly normal in height and weight.

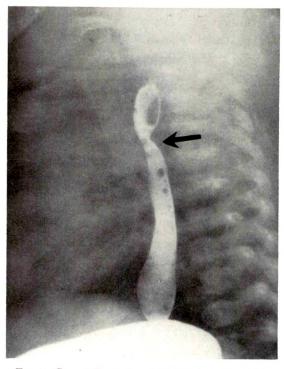


Fig. 2. Case i. Posterior esophageal compression due to left aortic diverticulum.

#### EMBRYOLOGY

In the developing fetus, a common arterial trunk just distal to the heart gives off a series of 6 paired branchial arches that connect the paired dorsal and ventral aortae. At about the 13 mm. stage, the right fourth arch begins to slowly obliterate, and the remainder forms the proximal subclavian artery. The left fourth arch persists as the ascending aorta.

The initiating mechanism for this developmental process is still unknown. If the left arch begins to atrophy before the right, the vascular stream apparently holds the right arch open and it persists as an anomalous right aorta. This is normal in birds. Usually, the right pulmonic (fifth) arch disappears before the 13 mm. stage, and the left fifth arch forms the ductus arteriosus. When the left aortic arch obliterates and the right remains patent, however, the left

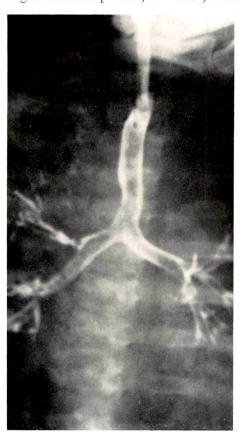


Fig. 3. Case i. Slight right tracheal indentation caused by right aortic arch.

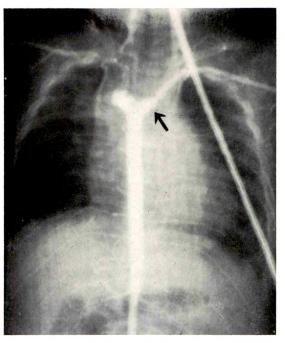


Fig. 4. Case I. Left aortic diverticulum with left subclavian artery arising from it. Coarcted proximal segment of the subclavian is visible.

subclavian artery usually has not completely ascended to its normal position. It then may arise from a retro-esophageal aortic diverticulum (Case 1). The ductus arteriosus is then attached either to the diverticulum or the left subclavian artery and a vascular ring is formed about the trachea and esophagus. Fibrous cords extending from the diverticulum to the left subclavian artery represent partially obliterated pulmonic arches and may add to the compression (Case II).

Any number of vascular anomalies may

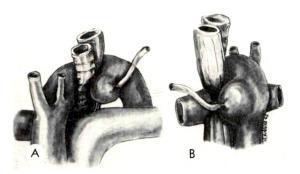


Fig. 5. Case I. Drawing of encircling vascular ring in (A) anteroposterior and (B) posterior views.

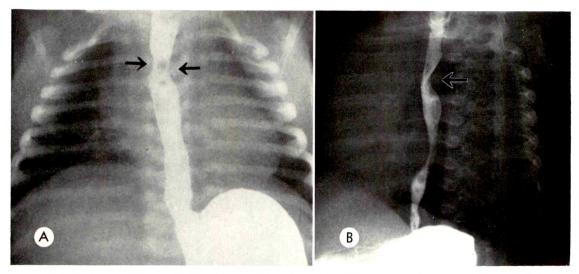


Fig. 6. Case II. (A and B) Bilateral esophageal compression due to right aortic arch and left ligamentum arteriosum. Marked posterior compression secondary to aortic diverticulum.

occur due to unexplained obliteration or persistence of the basic arch components. The described processes are primarily the abnormalities found in our 2 patients.

It is interesting to note that the mechanism which forms the diverticulum may be the precursor of aortic coarctation. Simultaneous atrophy of both fourth aortic arches, with completion of the process on

the right and sudden interruption on the left, will leave a large left "aortic diverticulum" which is followed by a narrowed segment and a small descending aorta.

#### COMMENT

Markedly improved surgical techniques have now removed the whole complex of vascular rings from their early role as post-

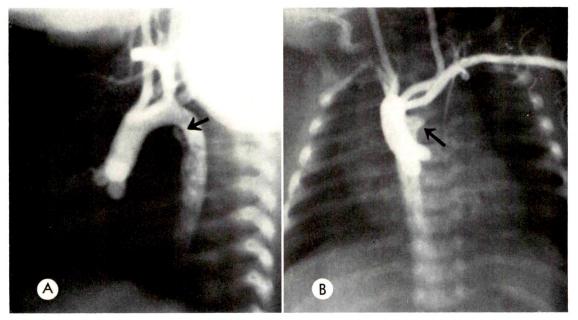


Fig. 7. Case II. (A and B) The aortic diverticulum is clearly seen. Note aberrant course of the left subclavian artery.

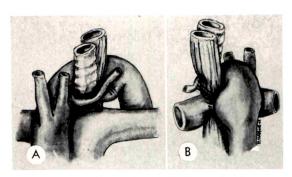


FIG. 8. Case II. (A) Anteroposterior and (B) posterior aspects of the vascular ring. The 3 cords extending from the diverticulum to the left subclavian artery represent obliterated pulmonic arches.

mortem curiosities and placed them in a category of congenital lesions that may be readily diagnosed and surgically corrected.

In 1943, Steinberg et al.<sup>11</sup> described 26 patients with a normal left aortic arch and patent ductus arteriosus in whom a "saccular aneurysm or localized dilatation of the descending arch" was found to lead into the ductus. No other vessels were reported to be attached to this outpouching. They postulated that this type of outpouching was either a traction aneurysm or a dilated infundibulum of the patent ductus. This structure is mentioned here only so that it will not be confused with the diverticulum.

A true diverticulum on a right aortic arch such as that found in our 2 patients was first reported by Arkin¹ in 1926. His findings were discovered at autopsy in a 50 year old man who died of generalized periarteritis nodosa. In addition, he described a ligamentum arteriosum connecting the diverticulum with the left pulmonary artery, and a stout cord connecting the left subclavian artery to the diverticulum.

The same year, Renander<sup>8</sup> published the first English language description of a right aortic arch diagnosed during life. There was no mention of a diverticulum.

A few brief references to a right aortic arch with diverticulum and encircling ligamentum arteriosum have appeared in the literature since then, but it was not until 1945 that Gross<sup>4</sup> described the successful surgical correction of various vascular



Fig. 9. Case II. Lateral view of the barium filled esophagus 2 months postoperatively shows persistence of indentation due to the diverticulum.

rings, including the type discussed in this paper. In 1949, Neuhauser<sup>7</sup> reported this triad, with the left subclavian artery arising from the diverticulum. Seven similar cases were reported by Sprong and Cutler<sup>10</sup> in 1930 and 1 by Watkins and Hering<sup>12</sup> in 1961.

The roentgen diagnosis of this triad should be relatively easily accomplished if the examiner is aware of the entity. Bilateral esophageal compression may be confused with double aortic arch, but fluoroscopic examination will reveal pulsations only on the right side. In older persons recognition of the diverticulum is possible on plain roentgenograms, but we were unable to visualize it in the small infant chest.

Of particular interest is the persistence of a posterior esophageal indentation after apparently successful relief of the encircling ring. In Case 1, autopsy showed a considerable degree of tracheo-esophageal deformity, with the diverticulum pressing against the esophagus. In Case II, an esophagram 2 months postoperatively showed a similar defect.

Definite release of the tight ring was established at surgery. It is also known that cartilaginous defects in the trachea may persist permanently from the pressure exerted against it during development; this in itself may account for the frequent mild respiratory problems observed after surgical correction. It is doubtful that the aortic diverticulum without other components of a vascular ring is productive of symptoms, since we often find it in asymptomatic patients with right-sided aortic arches.

#### SUMMARY

Two case reports of infants with vascular rings formed by a triad of right aortic arch, left aortic diverticulum and left ligamentum arteriosum are presented. Marked posterior compression of the esophagus by the diverticulum was the most prominent feature of the ring, and this persisted to a lesser degree postoperatively. In both cases, the vascular rings were diagnosed and surgically corrected before the age of 8 weeks.

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### ROENTGENOLOGIC EVALUATION OF NORMAL PULMONARY ARTERIES IN CHILDREN\*

By LAURENCE B. LEINBACH, M.D. WINSTON-SALEM, NORTH CAROLINA

DURING the roentgenologic evaluation of a patient with suspected heart disease, a critical analysis of the appearance of the pulmonary arterial tree is essential. Much of this analysis is subjective with the use of terms such as decreased pulmonary flow, increased pulmonary flow, abnormal tapering, etc., being used to indicate conditions as pulmonary stenosis, left-right shunts, and pulmonary hypertension.

In order to be more objective, actual measurements of arterial diameters and their relationship with each other in the same patient were felt to be necessary. In a survey of the literature, no reports were found in which the normal values for the pulmonary arteries in children were given. The purpose of this study is to present an evaluation of the caliber size of the normal pulmonary arterial tree in children as seen on routine frontal chest roentgenograms.

#### METHOD

Chest roentgenograms were reviewed of 243 children ranging in age from infancy to 14 years. Each roentgenogram fulfilled the following requirements before being used in the study: (1) technique and position were adequate; (2) diaphragmatic level was at least at the ninth posterior rib; and (3) the roentgenograms were interpreted as normal by the radiologist doing the original reading as well as by the author. The hospital charts were studied and the roentgenograms of patients with suspected heart disease and conditions which would alter normal growth were excluded even if they appeared normal.

The method of measurement was a modification of that described by Abrams. The

right lower lung field was utilized. A horizontal line was drawn from the descending branch of the right pulmonary artery just below the right hilar shadow to the lateral chest wall. A perpendicular line was then drawn inferiorly from the mid-point of this line to meet a horizontal line drawn bisecting the distance from the upper line and the cardiophrenic reflection. In this way, a central square-shaped area and a peripheral "L"-shaped area were obtained. Figure I illustrates this division of the right lower lung field into three parts.

After this division three measurements were made: (1) the diameter of the right descending pulmonary artery was measured as it appeared below the right hilus; (2) the diameter of the widest caliber secondary arterial branch was measured in the central area; and (3) the widest tertiary branch was then measured in the peripheral area. Frequently, the same branching artery could be traced through all areas; however, this could not always be determined accurately. The measurement of the widest arterial shadow in the two areas was necessary to ensure consistency because smaller arterial branches were seen in each area but their branching relationships were obscure. In each case three measurements were made on the main descending branch and an average diameter obtained. In the secondary and tertiary areas three measurements were made, either on the same artery or arteries of the same branching order, and an average value obtained.

In order to evaluate growth changes, bi-yearly age groups were chosen. In 92 individuals height and weight data were available. Surface area measurements were obtained from standard nomograms and

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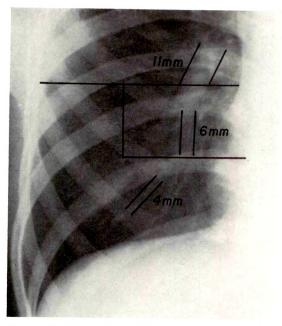


Fig. 1. Division of the right lower lobe into three areas with the arterial diameters shown in each area.

arterial diameters correlated with surface area.

#### RESULTS

Table I lists the results of the measurements of the primary, secondary, and tertiary branches of the right descending pulmonary artery as related to age groups and body surface area. This includes the number of individual cases in each group, the mean arterial size, and the standard deviation of each group. It can be seen that the age group of 0-2 years posed the greatest difficulty in measurement. Out of a total of 60 cases studied in this group, in only 25 was there sufficient arterial detail for accurate measurements. In the older age groups this problem was not encountered. As would be expected, there is a gradual increase in mean artery size with increasing age and body area. The standard deviations of each group remain constant in the age

 $T_{\rm ABLE~I}$  mean measurements of arterial diameters with standard deviations as related to age and body area

	P:	rimary Bra	anch	Sec	condary Br	ranch	T	ertiary Br	anch
Age (yr.)	No.	Mean (mm.)	Standard Deviation (mm.)	No.	Mean (mm.)	Standard Deviation (mm.)	No.	Mean (mm.)	Standard Deviation (mm.)
0- 2 2- 4 4- 6 6- 8 8-10 10-12 12-14	25* 16 25 49 26 39 28	6.1 7.3 8.4 9.1 9.1 10.0	1.2 1.0 1.0 1.1 0.7 1.1	25* 16 25 49 26 39 28	2.7 4.0 4.3 4.5 4.7 5.0 5.6	0.9 0.6 0.7 0.7 0.7 1.1 1.1	25 16 25 49 26 39 28	1.5 2.2 2.4 2.5 2.8 3.0 3.0	0.5 0.4 0.6 0.4 0.5 0.5
Total	208								
Area (m²) 0.21-0.4 0.41-0.6 0.61-0.8 0.81-1.00 1.01-1.20 1.21-1.40	11 9 18 23 17	5.8 6.5 8.3 9.6 10.0	1.0 1.4 0.8 1.2 1.1	9 8 18 23 17	3.1 3.5 4.0 4.8 5.1 5.1	1.6 1.1 0.7 0.7 0.7 0.7	11 9 18 23 17	1.4 1.8 2.3 2.5 2.8 3.0	0.4 0.6 0.5 0.5 0.6 0.7
Total	92								

<sup>\*</sup> Out of 60 normal infant chest roentgenograms only 25 could be measured.

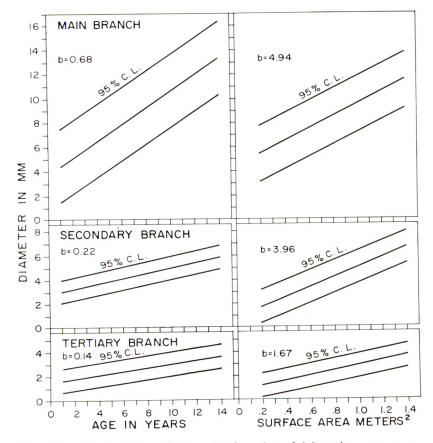


Fig. 2. Sample regressions of descending branches of right pulmonary artery as function of age and surface area.

and surface area groups; however, due to the lower mean values in the younger groups, there is a relative greater spread from the mean.

In order to document a definite relationship between growth in age or surface area and arterial diameter, correlation coefficients (r) for each large group were calculated using the formula:

$$r = \frac{N(\Sigma x_1 x_2) - (\Sigma x_1)(\Sigma x_2)}{\sqrt{\left[N(\Sigma x_1)^2 - (\Sigma x_1)^2\right] \times \left[N(\Sigma x_2)^2 - (\Sigma x_2)^2\right]}}$$

Where N=number in group (210 in age group, 92 in surface area group)  $x_1=$ individual artery measurements and  $x_2=$ individual age and/or body area in square meters. These results are tabulated in Table II.

With these high degrees of correlation

(p<1:1,000), the arterial diameters were then evaluated as dependent variables on both age and surface area. These linear regression curves are presented in Figure 2 with their respective 95 per cent confidence limits. An example as to how these graphs would be used is: A child aged 8 would be expected to have a main descending branch arterial diameter from 6.3–12.3 mm., secondary branch 3.6–5.5 mm., and a tertiary

TABLE II
CORRELATION COEFFICIENT

	Age	Body Area
Primary Branch	0.70	0.80
Secondary Branch	0.84	0.86
Tertiary Branch	0.70	0.65

p < 1:1,000

TABLE III

CALCULATED MEAN RATIOS OF PRIMARY BRANCH TO TERTIARY BRANCH WITH STANDARD DEVIATIONS

Area (m²)	No.	Mean Ratio	Standard Deviation (mm.)
0.23-0.40	ΙΙ	4.7	Ι.Ι
0.4 -0.6	9	3.8	0.96
0.61-0.8	18	3.8	I.2
0.8 -1.0	23	3.9	0.83
I.I -I.2	17	3.7	0.9
1.21-1.4	14	3.5	Ι.Ο
Age	No.	Mean Ratio	Standard Deviation (mm.)
O- 2	25	4.3	1.2
2- 4	16	3.5	0.8
4-6	25	3.7	I.O
6-8	49	3.8	0.88
8-10	26	3.4	0.7
10-12	39	3.4	0.6

branch 1.7-3.7 mm. in diameter. These graphs were constructed using individual measurements in the age and surface area groups. The formula for these regression curves is:

$$\hat{\mathbf{v}} = \bar{\mathbf{y}} + b(\mathbf{x} - \bar{\mathbf{x}}),$$

where  $\hat{y}$  is the estimated deviation of y related to a corresponding x deviation, x is individual determination of the arterial diameter,  $\bar{x}$  is mean value of x, b is the regression coefficient (values of b are given for each graph) and  $\bar{y}$  is the mean value of y.

The relationship of artery size in individuals was then analyzed and a ratio between the diameter of the main descending branch with that of a tertiary branch was calculated. The mean values and the stand-

ard deviations for each age and surface area group are given in Table III.

#### DISCUSSION

From the data presented the following information can be obtained: (1) infants are difficult to evaluate. Out of 60 normal chest roentgenograms analyzed in the o-2 age group, in only 25 was the arterial visualization discrete enough for accurate measurements. The majority of individuals in the group of 25 were over I year of age; (2) there appears to be a progressive uniform growth in pulmonary artery size with body growth and increasing age; (3) there is a close correlation between the age groups and the surface area groups, indicating the expected relationship between age and surface area in normal children; and (4) there is a constant and normal tapering relationship between the primary descending branch and the tertiary branches as indicated by the mean ratios.

These data are considered as standards for the diameter of pulmonary arteries of the right lower lobe in normal children. It is hoped that with their aid abnormal variations may be more accurately evaluated than has been previously possible.

#### CONCLUSION

Chest roentgenograms of a group of normal children have been studied in regards to the diameter of the pulmonary arterial branches. The data have been statistically analyzed and are submitted as normal standard values.

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## ROENTGEN EVALUATION OF PULMONARY ATRESIA WITH INTACT VENTRICULAR SEPTUM\*

By STEPHEN A. KIEFFER, M.D.,† and LEWIS S. CAREY, M.D.‡

O BSTRUCTION to the flow of blood from the right side of the heart into the pulmonary artery is the characteristic feature of a group of congenital cardiac malformations which includes pulmonary atresia, tricuspid atresia, and tetralogy of Fallot. In the newborn or neonatal infant who is symptomatic, pulmonary atresia with intact ventricular septum is the most frequent of these 3 lesions.

Although this is not one of the more common congenital cardiac malformations, a review of the case material at the University of Minnesota Hospitals in the 6 year period from 1956 to and including 1961 disclosed 20 cases proven at autopsy or on the operating table. It is the purpose of this communication to review the roentgen findings in this malformation with special emphasis on the forward (venous) angiocardiogram.

#### PATHOLOGY

Elliott and Edwards<sup>4</sup> have recently reviewed the pathologic findings in 12 of the 20 cases included in this study. The essential lesion is a complete obstruction at the pulmonary valvular level. A fibrous diaphragm is present at this level which is imperforate. The presence of an intact ventricular septum and an atretic pulmonary valve results in extremely high pressures within the right ventricular cavity. This in turn produces a preferential shunting of blood in the right atrium away from the tricuspid valve and through the patent foramen ovale into the left atrium. Thus, since little blood enters or leaves the right ventricle, that chamber usually fails to develop to a normal capacity.

In some cases, however, the tricuspid

valve is functionally incompetent, resulting in a lower pressure within the right ventricular chamber and allowing greater ingress and egress of blood.<sup>3</sup> In these patients, the capacity of the right ventricle is normal or even increased. In a recent review of the case material at the Mayo Clinic, Davignon and his associates<sup>3</sup> found 7 instances of pulmonary atresia associated with a large right ventricle while 13 cases had a tiny or small right ventricle. In our series, 12 had a small chamber and 8 a large one.

The right atrium is always enlarged. Because of the large shunt through the patent foramen ovale, the left atrium as well is enlarged but not to the degree of the right. Blood flow from the left atrium is in a normal course through the mitral valve into a left ventricle which is enlarged with hypertrophied myocardium. This chamber is doing the pumping for both the systemic and pulmonary circulations. Blood pumped into the aorta can enter into the pulmonary circulation by way of a patent ductus arteriosus. If the ductus closes, no other significant source of blood to the pulmonary circulation remains and the patient expires. In many cases, however, the ductus remains patent and supplies a pulmonary arterial system which is usually hypoplastic.

Elliott and Edwards<sup>4</sup> emphasize the anatomic changes associated with the markedly elevated right ventricular pressure. In 10 of the 12 patients, they noted an Ebstein type of deformity of the septal leaflet of the tricuspid valve, this leaflet inserting below the annulus fibrosus. However, only in those cases with a large right ventricular cavity did they feel that the tricuspid valve was functionally incompe-

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tent. In the cases where the tricuspid valve was functionally competent, they noted the development of large sinusoidal spaces in the myocardium which in effect provided a passage for small amounts of blood from the right ventricular cavity to the coronary arterial circulation. In all of these cases, the anterior descending branch of the left coronary artery was hypertrophied with a wide lumen showing evidence for at least partial reversal of flow in that vessel.

#### CLINICAL FEATURES AND PROGNOSIS

Cyanosis is the most prominent clinical feature. It occurs early and persists unless the baby is maintained in an atmosphere with elevated oxygen concentration. Within a short time, congestive heart failure supervenes. The age at death was under 2 months in 12 of our 17 autopsy cases. Only one patient lived beyond the age of 9 months, surviving to the age of  $3\frac{1}{2}$  years.

The electrocardiogram is of invaluable aid in the diagnosis of this malformation. Prominent P-waves reflect the marked enlargement of the right atrium. The limb leads show a normal or right axis deviation pattern. There is usually left ventricular preponderance on the precordial leads.

Survival of the infant depends on the patency of the ductus arteriosus. When this closes, the only significant supply of blood to the pulmonary circulation is cut off and rapid death ensues. Recently, 3 patients with pulmonary atresia were successfully operated upon at this institution. Pulmonary valvulotomy was performed, and thus far all 3 patients are doing well. The advent of successful surgical management of this otherwise fatal lesion emphasizes the importance of early diagnosis.

#### ROENTGEN ASPECTS

The most striking clinical finding in pulmonary atresia is a deficiency in the pulmonary circulation manifesting itself as cyanosis. The most significant finding on plain roentgenograms of the chest is also this circulatory insufficiency in the lungs. Pulmonary vascular markings are always

markedly decreased. Although a healthy infant taking a maximal inspiration at the depth of a cry may show decreased prominence of the pulmonary vascular markings, this never approaches the degree seen in association with pulmonary atresia.

Cardiomegaly is usually present. In those cases where the right ventricle is a tiny chamber, the cardiac silhouette is only slightly enlarged above the limits of normal. However, where the right ventricular cavity is large, the cardiac silhouette is also markedly enlarged and fills a great portion of the chest (Fig. 1).

Specific chamber enlargement is also reflected on the chest roentgenograms. The markedly enlarged right atrium produces a bulging of the lower half of the right cardiac border. In some cases, this may attain aneurysmal proportions (Fig. 3). If thymus tissue is not prominent, one may note an additional convexity superior to the right atrium. This is due to the lateral displacement of the superior vena cava by an enlarged aorta.

The pulmonary artery segment of the left heart border is always flat or concave, reflecting the diminished size of the pulmonary artery due to lack of flow through the pulmonary valve. The enlarged and hypertrophied left ventricle produces a prominent convexity in the lower left cardiac border which is directed more laterally than inferiorly. Lateral and oblique views demonstrate the usually moderate enlargement of the left atrium.

The configuration of the heart in pulmonary atresia is not specific on the plain roentgenograms. Both tricuspid atresia and pseudotruncus (pulmonary atresia with ventricular septal defect) may give a similar appearance.

#### ANGIOCARDIOGRAPHY

Of the 20 cases included in this study, biplane forward angiocardiograms were available in 11. In 9 of these angiocardiography was performed using the saphenous vein as the site of injection, while in 2 the antecubital vein was used. In either

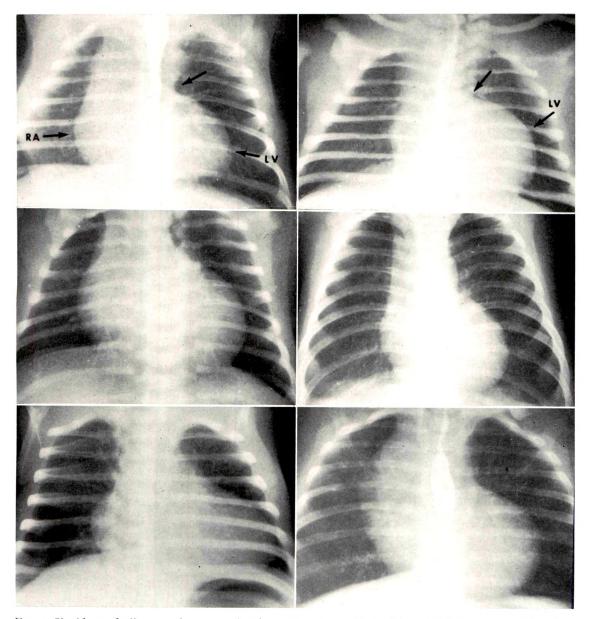


Fig. 1. Significant findings on the conventional roentgenogram. Upper left and right: Posteroanterior views demonstrate the concavity of the left heart border in the region of the pulmonary artery segment (unlabelled arrow) and the convexity of the lower portion of the left heart border due to the enlarged left ventricle (LV). The enlarged right atrium produces a mild convexity of the right heart border inferiorly (RA). Note the generalized diminution in size of the pulmonary vasculature. Center left and right: Roentgenograms demonstrate the range in heart size exhibited by patients with a tiny right ventricle. Lower left and right: The roentgenogram on the left shows gross cardiomegaly. At autopsy, the patient was found to have a large right ventricular cavity with an incompetent tricuspid valve. Roentgenogram on the right shows mild cardiomegaly in a patient found at operation to have a normal sized right ventricle.

case, contrast medium outlines a vena cava which is not dilated. The bolus of contrast material then enters the enlarged right atrium. In most cases, the contrast medium

appears to stream directly through the right atrium and the patent foramen ovale (Fig. 2, A and B). Usually, it is only after the left atrium is opacified that dilute con-

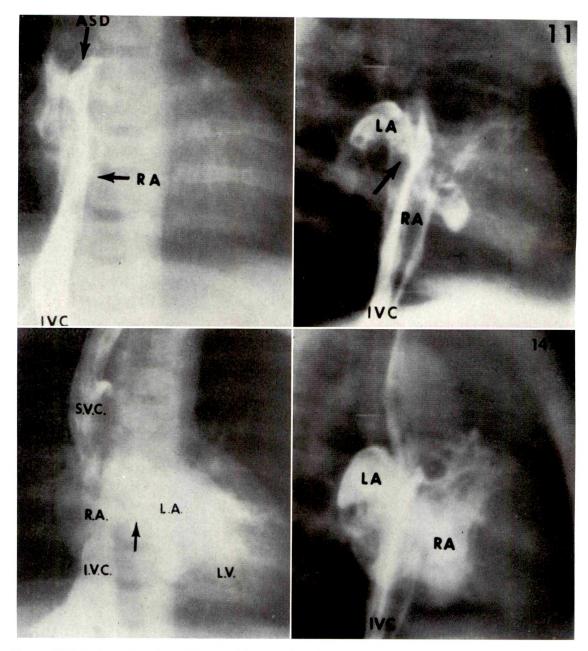


Fig. 2. Biplane forward angiocardiograms. These angiocardiograms and all in succeeding figures were made at a rate of 5 per second. The numbers on these angiocardiograms and on all succeeding figures refer to the sequential position of the film in each study. Upper left and right: Early angiocardiograms demonstrate the streaming of contrast medium in a column from the inferior vena cava (IVC) through the right atrium and into the left atrium by way of an atrial septal defect (ASD). The arrow on the lateral film points to the location of the atrial septal defect. Lower left and right: Angiocardiograms made 0.6 seconds later demonstrate reflux into the superior vena cava (SVC) and the proximal portion of the azygos vein. The contrast bolus now opacifies the left atrium (LA). The unlabelled arrow on the anteroposterior angiocardiogram points to the apex of the "right ventricular notch" which actually represents an area of right atrium not yet filled with contrast medium.

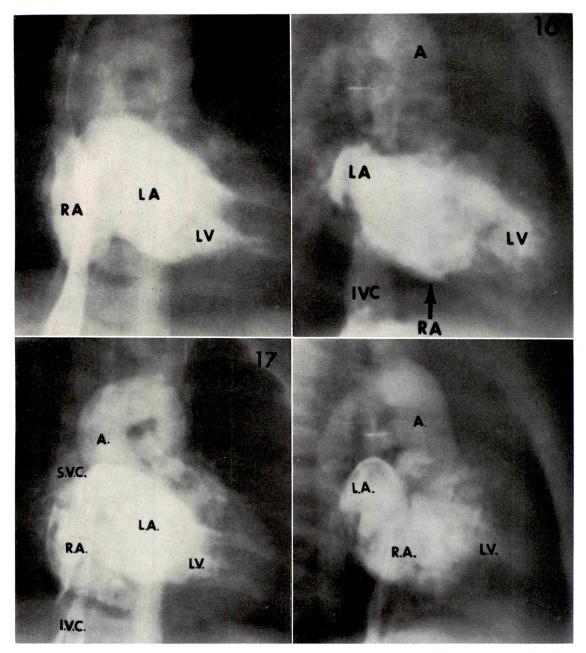


Fig. 2. (continued) Upper left and right: 0.4 seconds later, contrast material now fills more of the right atrial chamber and obscures the "right ventricular notch." The left ventricle and aorta (A) are faintly opacified. The hypertrophied wall of the left ventricle is visualized. On the lateral angiocardiogram an area of unopacified heart density lying anterior and superior to the left ventricle represents the location of the small right ventricular cavity. Lower left and right: 1.2 seconds after the first set of angiocardiograms in this figure, all chambers of the heart except the right ventricle are well delineated by contrast medium. The enlarged left atrium is densely opacified. The pulmonary trunk has filled by means of the ductus arteriosus which is seen on the lateral angiocardiogram.

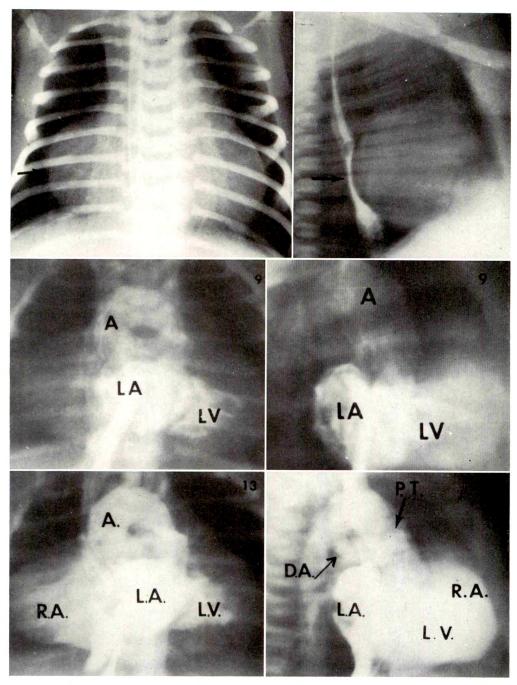


Fig. 3. Upper left and right: Conventional roentgenograms demonstrate aneurysmal dilatation of the right atrium on the frontal projection. The lateral projection shows the typical left atrial enlargement (arrow). Center left and right: Early angiocardiograms show streaming through the right atrium with dense filling of the left atrium and early filling of the left ventricle and aorta. Lower left and right: Later angiocardiograms show diffuse opacification of the enlarged right atrium. The pulmonary trunk (PT) has filled via the ductus arteriosus (DA).

trast medium spreads peripherally to outline the markedly enlarged right atrial cavity.

Having passed through the atrial septal defect in a column, the bolus of contrast appears to describe an arc around the superior and posterior walls of the left atrium. This arc is well shown on lateral films where the left atrium is seen to lie posterior and somewhat cephalad to the right atrium (Fig., 2, A and B; 4; and 5, A and B). The contrast medium then appears to curve in an anterior direction and passes through the mitral valve. The left atrium as it is outlined by this arc is seen to be somewhat enlarged but not to the degree of the right atrium. Contrast material tends to fill this chamber quite densely before passing into the left ventricle. Again, this phenomenon is better visualized in lateral films than in frontal projections.

Once the mitral valve opens, the opaque medium is seen to traverse the left ventricle in exceedingly short time. When the left ventricle is filled with contrast material, its hypertrophied wall is visualized. At this point in the examination, contrast medium almost entirely fills the cardiac silhouette. The enlarged right atrium is faintly but definitely outlined, the left atrium is seen as a smaller but more densely filled chamber, and the left ventricle is sharply outlined by its smooth interior surface (Fig. 2, A and B).

Because it carries virtually the entire supply of both the pulmonary and systemic circulations, the ascending aorta is invariably enlarged. Lateral films show a normal posterior location of the aortic root. Subsequently, the arch of the aorta is outlined and the ductus arteriosus fills. This vessel varies in diameter as well as in length. If the ductus is seen to be a wide vessel, the pulmonary trunk may be filled in a retrograde fashion down to the level of the valve. Peripheral pulmonary arteries also fill but are generally seen to be small and often no larger than tiny threads. It is to be emphasized that the pulmonary

trunk is not always visualized with contrast medium. In the 3 cases which survived pulmonary valvulotomy, preoperative angiocardiograms all showed filling of a near normal sized pulmonary arterial trunk (Fig. 6 and 7).

#### COMMENT

In the sequence of chamber filling described above, at no time were we able to observe the right ventricle filling with contrast medium. This was true whether the right ventricle was a tiny chamber or a large one. In those few cases where contrast material tended to spread diffusely in the right atrium before traversing the interatrial septum (Fig. 4), it may indeed have entered the right ventricular chamber, but this could not be definitely identified as such due to the presence of contrast material in the enlarged right and left atria. As a result, we were also unable to delineate with contrast medium the anomalous coronary sinusoids described above. In the case of the large right ventricle, the lack of filling of that chamber with contrast material may be related to the high pressure stream of regurgitant blood through the incompetent tricuspid valve. High pressures within the right ventricle may also play a major role in the usual streaming of contrast medium directly through the atrial septal defect into the left atrium.

The presence of a "notch" sign on the frontal projection in pulmonary atresia and also in tricuspid atresia has been cited previously as the location of the unopaciright ventricular chamber. This fied "notch" constitutes a portion of unopacified cardiac density forming a triangle with its base upon the diaphragmatic surface of the heart and its apex in the middle of the cardiac shadow. We were able to identify this "notch" on several of these angiocardiograms where triangular regions of unopacified heart were seen on early films in the frontal projection (Fig. 2A). However, later films in these patients demonstrated opacification of this region as the right atrium and to a lesser extent the

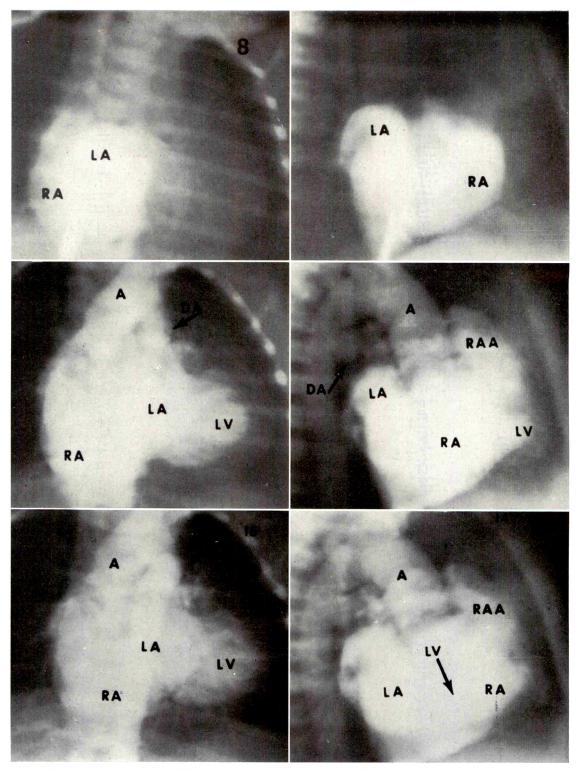


Fig. 4. Biplane forward angiocardiograms. Upper left and right: Early angiocardiograms demonstrate diffuse opacification of the right atrium. This is an unusual finding so early in the examination. Center left and right: Films show the location of the enlarged right atrium. On the lateral film, the right atrial appendage (RAA) overlies the proximal portion of the pulmonary trunk and the tiny right ventricular cavity. Lower left and right: Later angiocardiograms demonstrate the thick walled left ventricle. On the anteroposterior projection a circular density overlying the descending thoracic aorta and labelled DA represents the ductus arteriosus superimposed upon the pulmonary trunk.

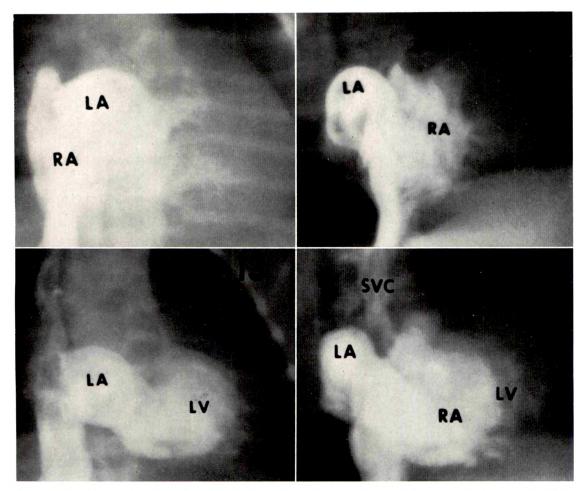


Fig. 5. Biplane forward angiocardiograms. Early angiocardiograms show a diffuse spread of contrast medium within the right atrium as the left atrium fills.

left ventricle filled with contrast material in their peripheral portions.

Correlation of this "notch" with the location of the right ventricle on the autopsy specimen simply does not exist. The right ventricular cavity is located high on the anterior surface of the heart just below the level of the valvular atresia. In none of the cases with a small right ventricle did the inferior extent of the right ventricular cavity approach the diaphragmatic surface of the heart. We therefore believe that the "notch" represents only an unfilled area of the right atrium and left ventricle in an early stage in the progression of contrast medium as it streams from the right atrium into the left atrium. The apex of the "notch" is formed by contrast medium passing through the interatrial septal defect. In one case we are able to identify an area free of contrast medium on the anteroposterior surface of the heart (Fig. 2B). This is the anatomic location of the right ventricle in pulmonary atresia with intact ventricular septum.

Differentiation between pulmonary atresia with intact ventricular septum and pulmonary atresia with ventricular septal defect (pseudotruncus) can usually be made without difficulty on the angiocardiogram. In the latter instance, a definite right ventricular cavity can be made out, and contrast medium can be seen to flow from the right atrium to the right ventricle and then to pass into the aorta.

However, the angiocardiographic differ-

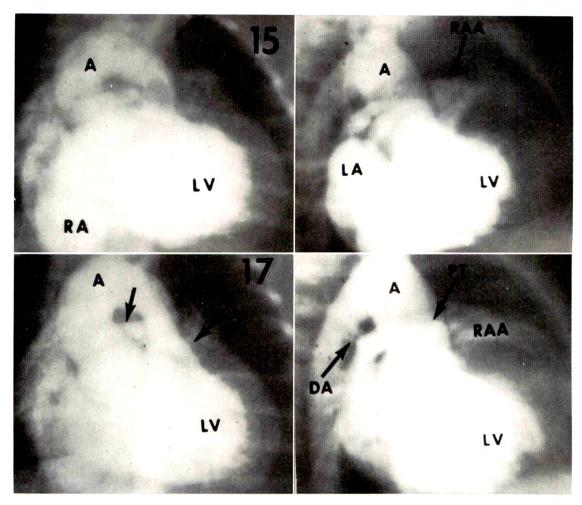


Fig. 5. (continued) The right atrial appendage (RAA) overlies the proximal portion of the pulmonary trunk (PT) on the lateral angiocardiograms. Note the band of increased density overlying the supravalvular portion of the ascending aorta representing the distal portion of the pulmonary trunk filled with contrast medium. This band is also demonstrated on the lateral films in Figures 2B, 3, 4, 6 and 7. Anteroposterior angiocardiogram No. 17 shows filling of the right and left pulmonary arteries which are labelled by arrows.

entiation of pulmonary atresia with intact ventricular septum is more difficult. Mode of filling and size of cardiac chambers in each malformation may be similar. One useful differential feature is the way in which the great vessels opacify. In tricuspid atresia the associated ventricular septal defect may allow simultaneous opacification of aorta and main pulmonary artery. Castellanos *et al.*<sup>1</sup> recently described the angiographic findings in tricuspid atresia. They noted definite dilatation of the inferior vena cava in some but not all of our

cases of pulmonary atresia with intact ventricular septum was well within normal limits as to size. We have also observed several cases of tricuspid atresia with this "mega vena cava" sign. The significance of this sign is not yet known.

The importance of filling of the pulmonary trunk is to be emphasized. If the ductus is large and the pulmonary trunk patent down to the level of the atretic valve, pulmonary valvulotomy is indicated and can be a life saving procedure.

If the clinical condition of the patient permits, selective aortography may be of

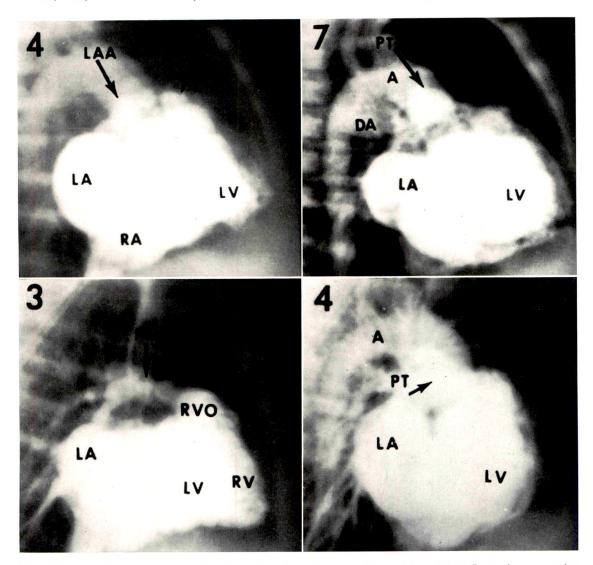


Fig. 6. Preoperative and postoperative forward angiocardiograms. *Upper left and right:* Lateral preoperative angiocardiograms demonstrate the usual sequence of filling with retrograde opacification of the pulmonary trunk demonstrated on film No. 7. *Lower left:* Angiocardiogram made following pulmonary valvulotomy shows a normal sequence of filling of the right ventricular outflow tract (RVO) and then of the pulmonary trunk (PT) prior to any filling of the aorta. Note that shunting across the atrial septal defect continues to occur. *Lower right:* Angiocardiogram film made 0.2 seconds later outlines the aorta and the still patent ductus arteriosus.

value in those cases where the forward angiocardiogram fails to delineate the pulmonary trunk. The catheter can be positioned at the approximate site where the ductus arteriosus joins the aorta. Retrograde flow of the contrast medium will define the size of the pulmonary trunk and should also demonstrate the atretic pulmonary valve.

It is likewise apparent that if right ventricular size is also to be evaluated preoperatively, the forward angiocardiogram is not the procedure of choice for delineation of this chamber. Rather, a catheter should be passed into the right atrium and an attempt made to catheterize the right ventricle. Selective angiocardiography can then be performed from within this

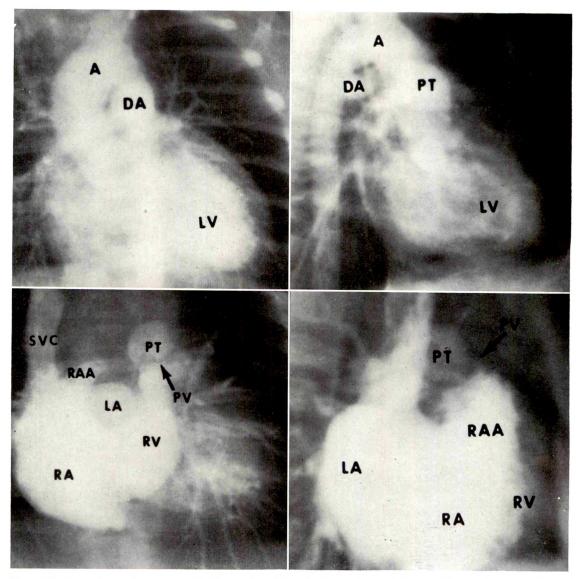


Fig. 7. Preoperative and postoperative forward angiocardiograms. *Upper left and right:* Anteroposterior and lateral angiocardiograms prior to valvulotomy show filling of the pulmonary trunk via the ductus arteriosus. *Lower left and right:* Angiocardiograms made after pulmonary valvulotomy show a normal sequence of filling of the right ventricle and then of the pulmonary trunk. The pulmonary valve (PV) is well outlined. Note on the lateral angiocardiogram that the right atrium almost completely obscures the contrast medium present within the right ventricle.

chamber, and a definitive answer may be obtained.<sup>2</sup> Failing this, the selective study should be performed from the right atrium.

#### SUMMARY

Pulmonary atresia with intact ventricular septum is a not uncommon congenital

malformation of the heart which becomes symptomatic at an early age and usually results in death.

The roentgen findings in 20 cases proven at autopsy or operation are reviewed. Findings on the plain roentgenograms include a diminution in pulmonary vascular markings and a variable degree of cardiomegaly, depending on the size of the right ventricle.

Biplane forward angiocardiograms were available in 11 of our cases. These showed streaming of contrast medium from the right atrium to the left atrium without any evidence for filling of the right ventricle. The significant point in the diagnosis of pulmonary atresia with intact ventricular septum is the demonstration of opacification of the pulmonary trunk via a patent ductus arteriosus. This is best detected in the lateral views where the opacified pulmonary trunk may be seen as a band of increased density superimposed on the opacified ascending aorta.

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### DECREASED VASCULARITY OF THE LEFT LUNG AND UNEQUAL AERATION OF THE LUNGS AS A MANIFESTATION OF PATENT DUCTUS ARTERIOSUS\*

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THE infant with congenital heart disease, characterized by a left-to-right shunt and associated with recurrent pulmonary infections and failure to thrive, presents a difficult diagnostic and therapeutic problem.8 A ventricular septal defect is the most common lesion responsible for this clinical pattern; however, not infrequently a patent ductus arteriosus may present this pattern. The differential diagnosis has considerable prognostic significance; small infants with serious dysfunction secondary to a ventricular septal defect do not respond well to medical management nor are they good candidates for surgical correction of their lesion by open heart techniques. By contrast, the patent ductus arteriosus is readily corrected and usually so even in small incapacitated infants.

The difficulty of establishing the diagnosis of patent ductus arteriosus during the first months of life is generally recognized.1,9,12,16,18 During this age period the murmur is often not "typical" in character or in location,6 and neither the electrocardiogram nor the roentgen examination of the chest is definitive. Special studies such as cardiac catheterization, angiocardiography and aortography are necessary in order to identify the site through which the left-to-right shunt is occurring. Because these studies may be technically difficult and are not without danger to the patient, a clinical finding which suggests a patent ductus arteriosus would have genuine value.

Several years ago an infant was seen by us who had respiratory distress, cardiac enlargement, persisting overaeration of the

left lung and diminished vasculature evident roentgenographically within the left lung as compared with the right. At the time of exploratory thoracotomy, a large patent ductus arteriosus was found, ligation of which resulted in complete relief of the patient's signs and symptoms (Case 1). Recently, another infant with similar symptoms and signs was seen. Experience with the first patient led to the correct diagnosis in the second, and the response to ligation of the patent ductus arteriosus was equally satisfactory (Case II). An older patient with clinical findings considered to be typical of those seen in children with patent ductus arteriosus also has been seen with similar roentgen abnormalities (Case III).

#### REPORT OF CASES

CASE I. J.G., a white female, was admitted to St. Christopher's Hospital for Children at the age of 6 weeks because of the finding of a cardiac murmur and of a "globular heart shadow" by roentgenographic examination. Physical examination was normal except for moderate tachypnea and a harsh systolic murmur along the left sternal border. The electrocardiogram was interpreted as showing mild right ventricular hypertrophy. Roentgenograms initially showed diffuse pulmonary infiltration, overageation of the lungs, cardiac enlargement and evidence of a left-to-right shunt. The clinical course was characterized by difficulties in feeding, occasional vomiting, failure to gain weight and intermittent episodes of increased respiratory difficulty. Roentgen examination of the chest revealed progressive overaeration of the left lung, and the pulmonary vessels appeared to be smaller in the left lung than in the right one (Fig. 1A). Bronchoscopy revealed no abnormality. A venous angiocardiogram revealed no

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anatomic abnormality of the right atrium or ventricle and no evidence of a right-to-left shunt. The branches of the pulmonary artery to the right lung were large; those to the left were small.

In view of the increasing severity of the clinical pattern and the progression of the roentgen findings (Fig. 1B), it was decided to explore the chest for an anomaly or an obstructive lesion of the left pulmonary artery. At 15 weeks of age, a thoracotomy was performed by Dr. Robert P. Glover, and a large patent ductus arteriosus was identified and ligated. No other cardiovascular or pulmonary abnormalities were noted. The imediate postoperative course was marked by rapid amelioration of the respiratory distress. The cardiac murmur was no longer

audible, and on discharge from the hospital the roentgen examination of the chest revealed the heart to be smaller and the pulmonary vasculature more nearly normal. The subsequent course has been completely uneventful, and the electrocardiogram and roentgenograms of the chest are now within normal limits (Fig. 1, C and D).

Case II. G.B., a Negro female infant, was admitted to St. Christopher's Hospital for Children at the age of 2 months because she required frequent rest periods during feeding and because there were episodes of breathlessness. Physical examination revealed moderate dyspnea but no cyanosis. The chest was hyperresonant to percussion, and there were subcostal retractions; expirations were prolonged, the

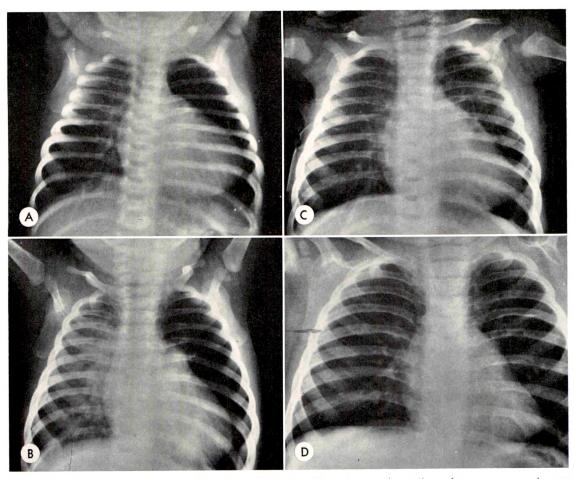


Fig. 1. Case I. (A) Roentgenogram of the chest at the age of 6 weeks reveals cardiac enlargement, prominence of the pulmonary artery, overfilling of the intrapulmonary vessels in the right lung and a paucity of vessels in the left lung. Both lungs are overaerated. (B) Roentgenogram at 3 months of age reveals more marked alterations of the intrapulmonary vasculature. Postoperative roentgenograms (C) at 9 days and (D) at 8 months, respectively, reveal equal aeration of the lungs and equal intrapulmonary vasculature.

breath sounds were louder over the right posterior thorax than over the left, and no rales were heard. A harsh systolic murmur was audible along the left sternal border.

An electrocardiogram was interpreted as showing right ventricular hypertrophy. Roentgen examination of the chest revealed cardiac enlargement, particularly of the right ventricle, increased blood flow to the lungs, inflammatory disease in the right upper lobe, and bilateral overaeration of the lungs (Fig. 2A). Slow clinical improvement occurred after treatment with antibiotics and digoxin, and the patient was discharged from the hospital. During the next 3 months, mild tachypnea persisted and was associated with occasional spells of coughing. Repeated physical examinations revealed diminished breath sounds over the left side of the chest posteriorly. At 5 months of age, she was re-admitted because of an acute episode of fever, diarrhea and an increase in respiratory distress. Roentgen examination of the chest revealed overaeration of the lungs, more marked on the left. The intrapulmonary vessels on the right were overfilled and large, while those on the left side were small and sparse (Fig. 2B).

During the next 2 months in the hospital, definitive cardiac studies (catheterization and angiocardiography) were repeatedly postponed owing to pulmonary infection, but were finally carried out at 7 months of age, despite the presence of atelectasis of the left lower lobe, because the infant's general condition was deteriorating. During cardiac catheterization, the patient developed severe bradycardia and an endotracheal catheter was passed for purposes of resuscitation. The oxygen content of all specimens taken during cardiac catheterization was very low due to hypoventilation and shock, and no left-to-right shunt was demonstrated. The right atrial pressure was 15/0, right ventricular pressure was 75/3, and pulmonary artery pressure was 75/40. Cineangiocardiography demonstrated prompt filling of two branches of the pulmonary artery to the right lung, a delay in passage of the contrast material through the smaller vessels to the left lung and the opacification of the arch and descending aorta through a patent ductus arteriosus (Fig. 2C). The following day, ligation of a large patent ductus arteriosus was carried out by Dr. Robert P. Glover. The left lung appeared grossly normal. A roentgenogram of the chest exposed in the immediate postoperative period and 2 months later (Fig. 2D) revealed more equal aeration and vascularity of the lungs. The postoperative

course was completely uneventful. At the time of discharge, the murmur was not audible and the patient was asymptomatic.

CASE III. R.L., a white male, II years of age, was admitted to St. Christopher's Hospital for Children because of the presence of a cardiac murmur which had been noted since the age of 6 weeks. There were no symptoms referable to the cardiovascular system. The only significant abnormalities noted on physical examination were a blood pressure of 142/0 and a harsh continuous murmur, best heard in the left subclavicular area. The electrocardiogram was interpreted as showing moderately severe left ventricular hypertrophy. Roentgen examination of the chest revealed moderate cardiac enlargement; the configuration of the heart suggested left-sided prominence; the intrapulmonary vasculature was more prominent than normal, with the increase being much more apparent on the right than on the left. Cardiac catheterization demonstrated a significant left-to-right shunt at the level of the pulmonary artery, where the pressure was increased to 50/28. Following ligation of the patent ductus arteriosus by Dr. J. C. Davila, the cardiac contour and pulmonary vasculature promptly reverted to normal.

#### DISCUSSION

In textbooks devoted to pediatric cardiology<sup>11,15</sup> and numerous articles<sup>2,3,4,7,10,13,14,17</sup> on patent ductus arteriosus in infancy, mention is not made of decreased vascularity of the left lung and/or overaeration of the left lung as a manifestation of this condition. Cottom and Myers<sup>5</sup> described 2 cases of "congenital lobar emphysema" in association with patent ductus arteriosus. Each of their patients had respiratory distress in early infancy. The first patient was treated by ligation of the patent ductus arteriosus, but developed such severe dyspnea in the immediate postoperative period that reoperation and lobectomy were necessary. Subsequently, in the treatment of a similar case, ligation of the patent ductus arteriosus and lobectomy were done at the same time. These authors emphasize that "correction of the cardiovascular defect is insufficient to relieve breathlessness in the presence of congenital emphysema," and suggest that the large pulmonary artery

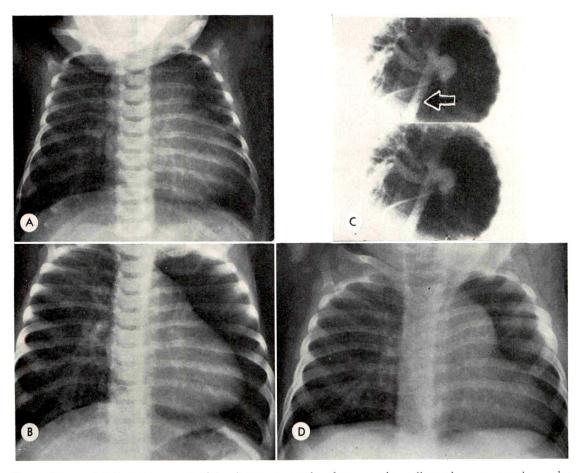


Fig. 2. Case II. (A) Roentgenogram of the chest at 2 months of age reveals cardiac enlargement and vascular overfilling in both lungs. (B) At 4 months of age, there was a definite difference in the vascularity of the lungs; the intrapulmonary vessels on the right are engorged, while those on the left are normal in size and distribution. (C) Cineangiocardiograms made during injection of contrast material into the pulmonary artery reveal filling of this structure and the aorta (arrow). Two branches of the pulmonary artery go to the right lung. There is less opacification of the branches of the pulmonary artery to the left lung than of those to the right one. (D) Roentgenogram of the chest made 2 months postoperatively reveals equal aeration of, and vasculature within, the lungs.

compresses an abnormal bronchus to produce emphysema. Unfortunately, the pathologic changes in the bronchus are not described. By contrast, our patients responded to simple ligation of the patent ductus arteriosus.

The mechanism of the pulmonary vascular changes and unilateral overaeration in our patients is not known. Intrinsic obstruction of the left stem bronchus would not be benefited by ligation of the patent ductus arteriosus. If the changes were due to simple extrinsic pressure on the left stem bronchus by a large pulmonary artery, by the ductus arteriosus or by an enlarged left

atrium, one would expect emphysema of the left lung to be a common finding in association with patent ductus arteriosus and other congenital cardiovascular defects characterized by increased blood flow to the lungs. During the 6 year period in which these 3 patients were observed, a total of 96 patients with patent ductus arteriosus was admitted to St. Christopher's Hospital for Children; in the same interval, there were 165 patients in whom a ventricular septal defect was the major defect. Thus it appears that the roentgen pattern here described may be limited to patent ductus arteriosus.

It is possible that the emphysema noted by roentgen examination was more apparent than real in that the decreased density of the lung was due mainly to the diminished vascularity to the left lung. Certainly, no intrinsic obstruction of the pulmonary artery would have been relieved by the surgery performed in our patients. Since ligation and not division of the ductus was done, the possibility that the diminished blood flow was due to a kink of the left pulmonary artery seems remote. It would seem most likely that the large flow of blood from the ductus arteriosus might enter the pulmonary artery in such a direction as to cause a suction effect on the left pulmonary artery (Venturi effect). Unfortunately, the left pulmonary artery was not entered during the catheterization of the second patient; however, pressures recorded during the catheterization of Case III were equal in the main pulmonary artery and in each of its branches.

#### SUMMARY

Three instances of patent ductus arteriosus associated with persistent overaeration of, and decreased vascularity within, the left lung have been described. The overaeration of the left lung and all clinical symptoms abated promptly following ligation of the patent ductus arteriosus. The possibility that this roentgen finding may be limited to patent ductus arteriosus is suggested; possible mechanisms responsible for the roentgen manifestations are discussed.

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# CONGENITAL STENOSIS OF THE RIGHT MAINSTEM BRONCHUS\*

By RICHARD E. LITT, M.D., L. FELIPE MENCIA, M.D., and DONALD H. ALTMAN, M.D. MIAMI, FLORIDA

THIS report will deal with a patient in whom recurrent pneumonia and atelectasis of the right lung were found to be secondary to stenosis of the right mainstem bronchus, and the possibility of this representing congenital stenosis of the right mainstem bronchus is considered.

#### REPORT OF CASE

C.M. (VCH#57554) was the product of a 7 month gestation with a birth weight of 3 pounds, 3 ounces. The neonatal course was not unusual, and the infant was discharged from the hospital at  $5\frac{1}{2}$  weeks of age, weighing 5 pounds, 8 ounces.

She was first admitted to Variety Children's Hospital at  $4\frac{1}{2}$  months of age, on October 10, 1959, with a history of vomiting, diarrhea, dehydration, and a rectal temperature of 106° F. A roentgenogram of the chest (Fig. 1) showed right upper lobe pneumonia. The patient became afebrile 24 hours after treatment with fluids and penicillin and was discharged 10 days later, at which time the chest roentgenogram was interpreted as normal.

She was re-admitted on November 3, 1959, with a history of chronic cough since the previous hospital discharge and with mild dyspnea of one day's duration. A chest roentgenogram showed right upper and middle lobe pneumonia. Again, treatment with penicillin and chloramphenicol resulted in improvement. During her stay in the hospital, tuberculin test, sickle cell preparation, and VDRL tests were negative.

She was re-admitted on February 2, 1960, at the age of 9 months, again, with a respiratory infection. A roentgenogram of the chest (Fig. 2) demonstrated right middle and upper lobe atelectasis. Culture of the nasopharynx showed *Staphylococcus aureus*. Sweat test, tuberculin and fungus skin tests, and sickle cell preparations were negative. Serum protein electrophoresis studies were within normal limits.

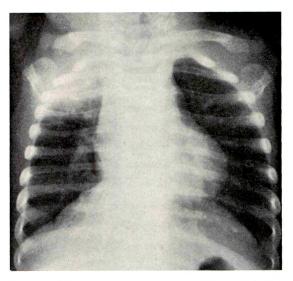


Fig. 1. Chest roentgenogram on first admission showing right upper lobe consolidation.

Again, the patient responded to antibiotic therapy.

The patient was followed in the Out-Patient department and was re-admitted on May 27, 1960, because a recheck roentgenogram (Fig. 3) showed persistent atelectasis of the right lung; the child, however, was relatively asymptomatic. Medical treatment resulted in marked roentgenographic improvement.

On August 14, 1961, at the age of 2 years, she was admitted to the hospital for the fifth time. At bronchoscopy, the bronchoscope could not be introduced into the right mainstem bronchus. A confirmatory bronchogram (Fig. 4) showed stenosis of the right mainstem bronchus with an otherwise normal tracheobronchial tree.

Thoracotomy was performed on September 1, 1961. Stenosis of the right mainstem bronchus extending for 1 cm. distal to the carina was found; the luminal diameter of the bronchus was only 3 mm. There was no evidence of aberrant vessel or of enlarged lymph nodes. Resection of the stenotic segment with an end-to-side

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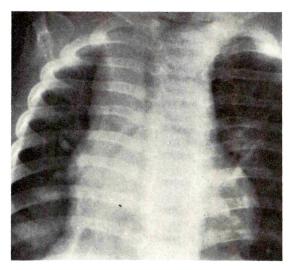


Fig. 2. Chest roentgenogram on February 2, 1960, demonstrates right upper lobe atelectasis. Note area of narrowing of right mainstem bronchus on the retouched roentgenogram.

anastomosis of the right bronchus to the lateral wall of the trachea was performed. Histologic examination of the narrowed segment showed mild chronic inflammation.

The postoperative course was completely uneventful, and a repeat bronchogram (Fig. 5) on October 25, 1961, revealed adequate luminal diameter at the anastomotic site with normal aeration of the right lung.

The child was seen at 3 and 6 months follow-

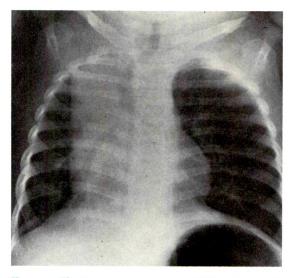


Fig. 3. Chest roentgenogram on May 27, 1960, demonstrating persistent atelectasis of right lung.

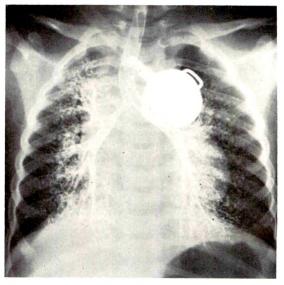


Fig. 4. A retouched bronchogram on August 14, 1961, clearly defining the right mainstem bronchial stenosis.

ing surgery and was completely asymptomatic. Chest roentgenograms were negative.

#### EMBRYOLOGY

The tracheolaryngeal outgrowth appears in the 4 week embryo. The distal end of this entodermal pouch has the appearance of two bulbous enlargements known as

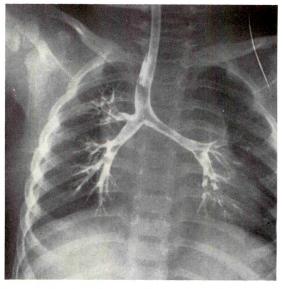


Fig. 5. Postoperative bronchogram revealing the site of resection and re-anastomosis. Note re-aeration of right upper lobe.

lung buds or primary bronchial buds. Cartilaginous rings of extrinsic mesenchymal origin are delineated by the ninth week. Bronchostenosis secondary to aberrant vessels is caused by a developmental error in the relationship of the tracheobronchial tree to the pulmonary artery and its branches. Previous classifications of bronchial obstruction (Jordan; Hollinger and Andrews) do not include congenital stenosis.

#### DISCUSSION

The diagnosis of "congenital" bronchostenosis in our patient was suggested after repeated studies, as we had no familiarity with this entity. The patient had had no respiratory difficulty until a few days prior to her first hospital admission at the age of  $4\frac{1}{2}$  months. At that time, narrowing of the right mainstem bronchus was present, in retrospect, on the plain posteroanterior roentgenogram of the chest. It could also be seen on all subsequent chest roentgenograms and was proven on the preoperative bronchogram.

Further substantiation of our impression is the exclusion of other causes of bronchostenosis, both clinically and at the time of thoracotomy.<sup>3,4,7</sup> The tuberculin and fungus skin tests were nonreactive, there was no aberrant vessel or lymph node enlargement at surgery, the bronchial anatomy was otherwise normal and section of the stenotic segment showed only "mild chronic inflammation."

Our review of the medical literature revealed no previous mention of a similar case or even classification to include this entity. It is nevertheless our assumption that this may represent a case of congenital stenosis of the right mainstem bronchus.

Recognition of the defect prompted surgical correction, and a satisfactory result

was obtained. In the future, awareness of the entity may offer earlier diagnosis.

#### SUMMARY

A case of probable congenital mainstem bronchial stenosis is presented. The main symptoms were those of repeated respiratory infections and collapse, limited to one lung.

The embryology of the laryngotracheobronchial tree is mentioned, but no explanation for this defect is hypothesized. We suggest the addition of this entity to the previous classifications.

A satisfactory surgical result was accomplished.

The possibility of congenital bronchial stenosis in the differential diagnosis of the etiology of repeated respiratory infections and/or collapse should be considered.

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# A FORM OF PULMONARY INSUFFICIENCY IN PREMATURE INFANTS\*

#### PULMONARY DYSMATURITY?

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 $\mathbf{R}^{\mathrm{ESPIRATORY}}$  distress occurring in the neonatal period in prematurely born infants is not uncommon and is usually the result of atelectasis with or without hyaline membranes, aspiration, infection, hemorrhage, or congenital anomalies. An additional and more unusual form of pulmonary disease, presenting a specific roentgenographic appearance, has recently been seen in small premature infants. In 1960, Wilson and Mikity<sup>7</sup> reported a series of cases in which the roentgenographic findings included diffuse, coarsely nodular or reticularly streaked pulmonary infiltrates with areas of emphysema, occasionally presenting a cystic appearance. Two of the 5 infants reported survived. The published chest roentgenograms and the clinical findings of these infants are similar to those of 6 additional infants we have recently seen in Boston, Baltimore, and Durham (Table IV). Three of these infants are alive and apparently well. Autopsies, done on 2 of the 3 who succumbed, showed pulmonary septal thickening and alveolar overdistention. The similarity in the clinical, roentgenographic and pathologic findings indicates that these cases probably have a common, although yet unknown, etiology.

#### CLINICAL FINDINGS

The clinical findings, summarized in Table I, are presented in the report of cases. All infants were born prematurely with birth weights from 860 to 1,600 gm. The only other complication of pregnancy was maternal hemorrhage in 4 cases. All were white, and there was no sex predilection.

The most consistent clinical feature was a dependence on oxygen to overcome cyanosis present from birth in 5 of the 6 infants. Cyanosis was not manifest in one infant (Case II) before 14 days of age. Rales were sometimes heard and subcostal retractions were noted. The latter were not of the severity seen in respiratory distress from many other causes. The respiratory rate was usually within the normal range, but was characterized by irregularity with periods of apnea and occasional episodes of tachypnea of 60 to 80 per minute. Wheezing was not heard. There was no elevation of temperature.

Gradual clinical improvement followed in the 3 infants who ultimately recovered with decreasing dependence on oxygen at 1 to 6 months of age and roentgenographic improvement at 6 to 8 months of age. Death in the remaining 3 resulted at 12 hours of age (Case v) from immaturity and respiratory failure, at 59 days of age (Case 1) from hydrocephalus and intraventricular hemorrhage, and at 4 months (Case III) from pulmonary insufficiency and aspiration.

#### LABORATORY FINDINGS

The results of the laboratory studies are summarized in Table II.

Hemograms. Since all the infants were born prematurely, the low hemoglobin at 2 to 3 months of age is not unexpected. White blood cell counts ranged from 7,000 to 20,000 cells/cu. mm. The white blood cell counts were elevated in infants who had intercurrent acute infectious episodes, but

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† John and Mary Markle Scholar in Academic Medicine.

Тав	LE I
CLINICAL	FINDINGS

Case	Race and Sex	Birth Weight (gm.)	Onset of Symptoms	Cyanosis	Respiratory Signs	Outcome
I. J.M.	WM	1,340	Birth	Yes	Rales Retractions Apneic spells	Dead—59 da.
II. B.M.	WF	1,180	14 da.	Yes	Retractions Alive— Tachypnea Apneic spells	
III. A.B.	WF	1,600	Birth	Yes	Retractions Tachypnea Rales	Dead—4 mo.
IV. D.B.	WF	1,540	Birth	Yes	No retractions Alive- Rales Irregular breathing out of oxygen	
V. B.W.	WM	860	Birth	Yes	Retractions Tachypnea Apneic spells	Dead—12 hr.
VI. M.G.	WM	1,550	Birth	Yes	Retractions Tachypnea	Alive—24 mo.

persistent elevation or a characteristic differential count was not observed.

Cultures. The organism most commonly recovered from the nasopharynx was *E. coli*. The frequency of this organism in premature infants is so great that its significance as a pathogen is doubtful. The more extensive bacteriologic and virologic investigations of Wilson and Mikity<sup>7</sup> failed to demonstrate a common pathogenic organism.

Other Studies. Tuberculin skin tests in 4 infants and histoplasmin tests in 2 infants were negative. Sweat chlorides in 2 infants were normal, and stool trypsin was present in the third. Examination of the urine for cytomegalic inclusion bodies was negative in I infant (Case II).

Electrocardiograms were normal in 3 infants.

In the 2 infants in whom carbon dioxide combining power was measured, it was 28 and 33 mEq./L. An arterial pH in 1 who

subsequently recovered (Case III) was 7.4 with an oxygen saturation of 75 per cent. The other (Case IV) had an arterial pH of 7.2 and CO<sub>2</sub> content of 40 mEq./L. just before death from pulmonary insufficiency.

The "crying vital capacity" of Case IV at 3 months of age (weight 4 kg.) was IIO ml. or 5 times the tidal volume. This volume is probably normal.

#### ROENTGENOGRAPHIC CHANGES

All the infants showed a distinctive and strikingly similar roentgenographic picture. The changes consisted of a diffuse, bilateral, coarse, lace-like pattern of infiltrates with alternating cyst-like foci. These foci varied from 2 to 10 mm. in diameter. The appearance suggested thickening of the interstitial supporting structures with intervening areas of hyperaeration. The overall lung volume was increased (Fig. 1, A and B; 2; 3, A, B and C; 5; 8; and 10). The cardiovascular structures were normal ex-

TABLE	II
LABORATORY	STUDIES

Case	Hemogram	Cultures	Skin Tests	Chemistries	EKG.	Miscellaneous
I. J.M.	Rh isoimmunization with 3 exchange transfusions. Age 2 mo. Het 21%; WBC 9,000. Differential-normal.	N.P.—E. coli				
II. B.M.	Age 1 da. Hb. 18 gm.; WBC 30,000. Differential-normal. Age 3 mo. Hb. 9 gm.; WBC 10,000-17,000.		OT—neg.			Urine negative for cy- tomegalic inclusion bodies. Barium swal- low normal at 6 mo.
III. A.B.	Age 2 mo. Het 35%; WBC 9,700. Age 3 mo. Het 44%; WBC 16,300; 24% pmn., 2% juv., 65% ly., 4% mo., 5% eo.	N.P.—E. coli	P.P.D.—neg.	3 mo. SUN 21 mg.% CO <sub>2</sub> 33 mEq./L. Cl 96 mEq./L. Na 136 mEq./L. K 5.7 mEq./L.	Normal	Sweat chlorides 20 mEq./L., normal Preterminal Arterial blood pH 7.21 CO <sub>2</sub> 40 mEq./L.
IV. D.B.	Age 3 mo. Hct 35%; WBC 9,700; 33% pmn., 11% juv., 50% ly., 6% mo.	N.P.—Staph, aureus T. E. coli	P.P.D.—neg. Histoplasmin —neg.	3 mo. Arterial pH 7.4 CO <sub>2</sub> 28 mEq./L. O <sub>2</sub> sat. 75%	Normal	Sweat chlorides nor- mal, Crying vital ca- pacity normal
V. B.W.		Blood-neg. CSF-neg.				
VI. M.G.	Age I mo. Hb. 7.8 gm.; WBC 15,500. Differential—normal.	Blood-neg. N.P. Staph. aureus; Strep.; E. coli	O.T. 1:1,000 —neg. Histoplasmin —neg.		Normal	Stool trypsin present

cept in Case IV in whom right ventricular enlargement was suspected on the conventional roentgenograms and prominence of the pulmonary artery was suggested on the angiocardiogram. The peripheral pulmonary vascularity was, however, not remarkable (Fig. 6). One of the infants who died (Case III) showed increasing emphysema with increase in the size of the overdistended cyst-like foci and associated compression of the adjacent parenchyma (Fig. 4).

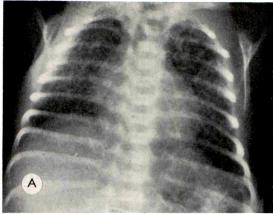
Roentgenographic clearing followed in the 3 surviving infants over a period of 8 to 12 months (Table III).

#### POSTMORTEM STUDIES

The lungs of the 2 infants examined at autopsy were hyperaerated and voluminous with glistening blebs measuring 1 to 2 mm. on the surface. This appearance was more evident on inflation of the lungs. Expansion of one lobe in Case III to a peak distending

pressure of 35 cm. of water resulted in a hobnail appearance of the lung surface with raised rounded areas measuring 0.5 to 2 cm. in diameter (Fig. 11). The air spaces appeared overdistended in the lobules, but the lung itself appeared restricted by the interlobular septa. No abnormalities in the airway or in the pulmonary blood supply or return was evident on gross examination. The tracheobronchial lymph nodes were not prominent. No cardiac abnormalities were observed.

The *histologic* features of these lungs consisted of septal thickening apparently by an increase in connective tissue and variation in the size and outline of the terminal airspaces with patchy emphysema and apparent decrease in alveolar divisions. An increase in the number of interstitial cells possibly representing septal cells was seen. Septal capillaries were 2 or more erythrocytes wide in some areas and were not visible in others. An intra-alveolar



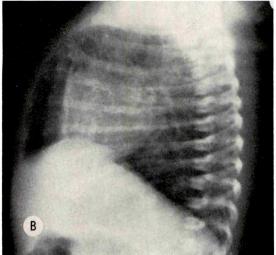


Fig. 1. Case 1. (A) Chest roentgenogram obtained at 8 days of age. The lungs show fine lace-like infiltration with cyst-like areas of radiolucency. (B) Lateral view demonstrates the significant degree of hyperaeration.

mononuclear response was present in some areas, and focal lobular hemorrhage was noted in Case III (Fig. 13 and 14).

The pressure-volume characteristics of one lobe in Case III, studied by a technique described previously,<sup>2</sup> demonstrated no restriction to expansion. The volume of air in the lung at the peak distending pressure of 35 cm. of water was 4.3 cc./gm. compared with 3.4 cc./gm. of lung tissue in a normal newborn infant of comparable weight. (There is, however, no information available for the expected behavior of the lung of an infant of this age.) The elastic recoil of the lung may be somewhat de-

creased since the volume of trapped gas was more than half the total capacity of the lobe (Fig. 12).

#### REPORT OF CASES

Case I. J.M. (Boston). This 1.34 kg. white male was born of a gravida 6, para 5, 28 year old mother. There was intermittent bleeding throughout pregnancy. The mother was Rh negative, sensitized. Delivery was precipitous, and the infant was cyanotic at birth. Subcostal and intercostal retractions were present. Three exchange transfusions were required for hyperbilirubinemia due to isoimmunization. The infant continued to have some retractions and cyanosis. Chest roentgenograms at 8 days of age showed the characteristic findings discussed above (Fig. 1, A and B).

The laboratory studies are shown in Table II. Diffuse rales, cyanosis, and apneic episodes continued over the next few weeks of life, with subsequent improvement in his pulmonary status and in the roentgenogram by 26 days of age.

His course was complicated by hydrocephalus and intraventricular hemorrhage, which resulted in death at 59 days of age.

The autopsy protocol states that the right lung weighed 27 gm. and the left lung 23 gm. Both were voluminous, pale, and crepitant with I-2 mm. glistening blebs over the entire surface.

The interlobar markings were retracted, dark, and accentuated. The bronchovascular structures were not accentuated. On histologic exam-

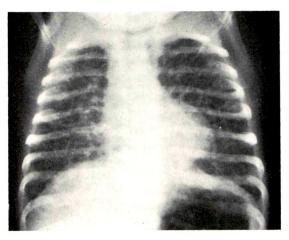
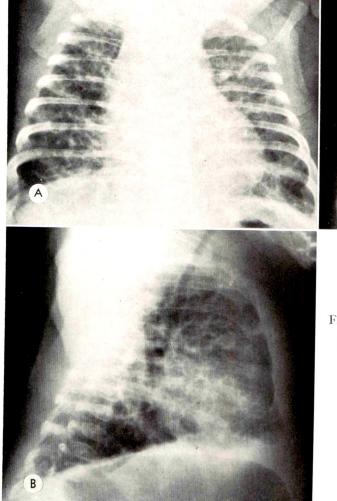


Fig. 2. Case II. Chest roentgenogram obtained at 15 days of age shows diffuse reticular infiltrates producing a "bubbly" appearance.



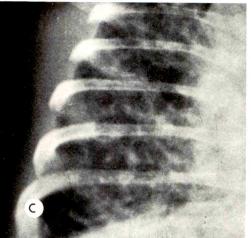


Fig. 3. Case III. (A) Chest roentgenogram obtained at  $2\frac{1}{2}$  months of age shows the diffuse lace-like pattern. (B) Lateral view demonstrates the flattened diaphragm and increased anteroposterior diameter of the chest. (C) Magnified view of right base.

ination, the air spaces were irregular, some were fairly large, but there was little evidence of alveolar formation. The septa were often thick and only congested in foci. There were a few islands of condensed tissue with round cell infiltrates (Fig. 13).

Case II. B.M. (Boston). This 1.18 kg. white female infant was born 3 months before term of a mother who had some vaginal bleeding 3 weeks before delivery. The membranes ruptured 17 hours before delivery. On the third day of life the infant received an exchange transfusion for hyperbilirubinemia of undetermined cause, and did well thereafter until 2 weeks of age, when apnea, cyanosis, and bradycardia occurred. Thereafter, decreased breath sounds,

rales, tachypnea and cyanosis persisted. A chest roentgenogram at this time showed the changes described above (Fig. 2). She received penicillin and chloramphenicol for a period of 10 days with clinical improvement, but roentgenographic evidence of persistent changes in the lungs.

Over the next 10 months she had 3 subsequent hospital admissions for exacerbation of her pulmonary symptoms, associated with infiltration in the lungs characteristic of pneumonia and, on one occasion, right upper lobe atelectasis and leukocytosis. She recovered from these episodes on appropriate antibiotic therapy. At 10 months of age she weighed 5.25 kg. and her length was 62 cm. At 12 months of age her chest roentgenogram was normal.

	TABLE	III	[	
ROENTO	GENOGRAF	ніс	PROGR	ESS

Case	First Roent- genogram	Follow-up Roentgenogram
I. J.M.*	8 da.	26 da.—some clearing
II. B.M.	15 da.	2.5 mo.—little change 6 mo.—some resolution 12 mo.—clear
III. A.B.*	4 da.	2.5 mo.—no change 4 mo.—increasing emphysema
IV. D.B.	4 da.	3 mo.—no change 8 mo.—some clearing 13 mo.—clear
V. B.W.*	9 hr.	Postmortem—pneumo- thorax (12 hr.), in- creased "cystic" disten- tion
VI. M.G.	I mo.	2 mo.—no change 8 mo.—clear

<sup>\*</sup> non-survivors.

Case III. A.B. (Baltimore). This 1.6 kg. white female infant was born 2 months before term to a 21 year old gravida 2, para 2. Pregnancy was complicated by profuse vaginal bleeding during the month preceding birth. The infant required resuscitation at birth until the first spontaneous breath at 13 minutes. She remained cyanotic, with mild retractions for the rest of her 4 months of life. The respiratory rate averaged 60 per minute. Rales were heard on occasion, but there was no stridor or wheezing.

She was treated with penicillin and chloramphenicol, and digitalized even though no hepatomegaly or cardiac enlargement was present. The heart rate was moderately elevated, with an average of about 160/minute. A course of prednisone, 10 mg. every 6 hours, started 4 days before death, was without effect. Despite the serious respiratory insufficiency, weight gain was progressive to 3.45 kg. at the time of death.

Laboratory studies are shown in Table 11.

Roentgenograms of the chest (Fig. 3, A, B and C) showed the changes described. A roentgenogram at 4 months revealed increasing overdistention of the lungs (Fig. 4).

At autopsy, examination of the thoracic

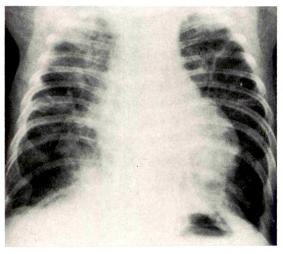


Fig. 4. Case III. Chest roentgenogram obtained at 4 months of age shows increase in the size of the radiolucent foci, compression of the adjacent parenchyma, and over-all increase in the degree of hyperaeration. Note the marked depression of the diaphragm; also, the healing fracture of the right seventh rib.

cavity revealed smooth pleural and pericardial surfaces with no free fluid. An 8 gm. bilobed thymus was present in midline. The heart and lungs together weighed 120 gm. The heart was normal; the ductus arteriosus was obliterated. The lungs showed patchy dark-red and gray areas. On cut section there was minimal edema in all areas. In the focal gray areas the lung appeared overdistended with some gas-containing areas measuring 8 mm. in diameter. The upper

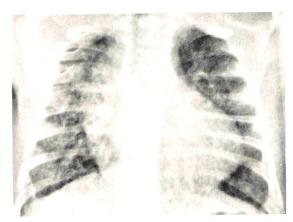


Fig. 5. Case IV. Chest roentgenogram obtained at 3 months shows diffuse lace-like infiltration resulting in a soap-bubble appearance. The thymus widens the right superior mediastinum. There is moderate cardiomegaly.

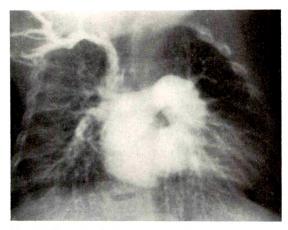


Fig. 6. Case IV. Anteroposterior intravenous angiocardiogram at 3 months of age at 2 seconds shows slight prominence of the main pulmonary artery. The peripheral pulmonary vascularity is normal.

airway contained some gastric contents. The esophagus was normal with no evidence of a fistula.

Microscopic examination of the lungs showed septal thickening, apparently by connective tissue increase, and a simplification of air space outlines as if alveolar development had been incomplete. There was variability in septal vascularity, some capillaries were 2 or more erythrocytes wide, others were not visible. Much of the lung was airless due to focal lobular hemorrhage and a mononuclear response. Other areas were well aerated. There were foci of extramedullary hematopoiesis.

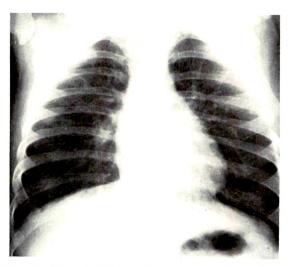


Fig. 7. Case IV. Chest roentgenogram obtained at 13 months of age shows complete clearing. The cardiac silhouette is normal.

Case IV. D.B. (Baltimore). This 1.54 kg. white female infant was born to a 22 year old mother 2 months before term following a stormy pregnancy characterized by profuse bleeding during the last 2 months. The mother received 7 pints of blood. The infant cried promptly, but was cyanotic from birth, and was kept in 28–30 per cent oxygen for the next 4 months. Fine

TABLE IV

Findings	Wilson and Mikity <sup>7</sup> (5 infants)	Authors' (6 infants)	
Maternal Hemorrhage	3	4	
Race: White Negro Other	2 2 1 Japanese- Mexican	6	
Sex: Male Female	3 2	3 3	
Cyanosis: Onset at birth Delayed	None 5, 10, 18, 25, and 35 days	5 14 days (Case II)	
Respiratory Signs: Retractions Tachypnea Apneic spells Wheezing	5 5 1 1	5 4 3 None	
Fever	None in 3 mentioned	None	
Electrocardiogram	Normal in 1 Abnormal in 3 Not men- tioned in 1	Normal in 3 Not done in 3	
Cardiac Failure	4	None	
Survivals	2	3	
Cause of Death: Pulmonary insufficiency Cardiac failure Miscellaneous Diarrhea Cerebral hemorrhage	I I	2 	

rales could be heard on deep inspiration. There were no retractions at rest, and the respiratory rate was 28–40/minute. Laboratory studies are presented in Table II. Chest roentgenograms at 4 days and 3 months showed the same appearance (Fig. 5). An angiocardiogram revealed a slightly prominent main pulmonary artery (Fig. 6). By 4 months of age she could remain acyanotic out of oxygen, had grown well, and was discharged from the hospital. At 7 months she had varicella with pneumonia, was hospitalized again, and recovered. At 8 months, her weight was 6.58 kg. and her length 64 cm. Her chest roentgenogram at that time showed remarkable clearing of the process and was completely clear at 13 months (Fig. 7). She was definitely retarded in motor development, unable to sit up, and markedly dolichocephalic.

Case v. B.W. (Baltimore). This 0.86 kg, white male infant was born of a 15 year old primigravida 3 months before term. The pregnancy was otherwise not complicated. The immediate condition of the infant is not known. Upon admission at 9 hours of age, he was dusky with a respiratory rate of 36/minute and 2–3 second periods of apnea. Retractions and rales were present. A roentgenogram of the chest at 9 hours of age showed the characteristic changes discussed above (Fig. 8). The infant expired at 12 hours of age, before other studies were done. An autopsy was not performed. A postmortem roentgenogram showed a pneumothorax and increased size of the cyst-like foci (Fig. 9).

Case vi. M.G. (Durham). This 1.55 kg. white male was delivered 9 weeks before term of a

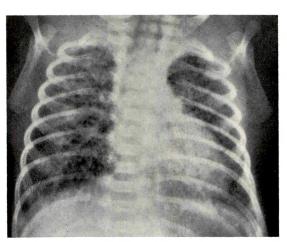


Fig. 8. Case v. Chest roentgenogram obtained at 9 hours of age shows diffuse reticular infiltration with very small foci of hyperaeration.

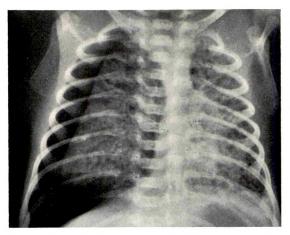


Fig. 9. Case v. Postmortem roentgenogram of the chest obtained at 12 hours shows a pneumothorax on the right possibly related to resuscitative efforts. There is increase in the size of the cyst-like foci on the left.

primigravida whose pregnancy was otherwise unremarkable. The infant breathed normally at birth, and did well save for his inability to remain pink out of oxygen. Respirations were 60/minute, with some retractions. A chest roentgenogram at I month of age showed the described changes (Fig. 10). Laboratory studies (Table II) did not elucidate the process.

He was treated with penicillin and tetracycline without apparent effect. It was gradually possible to wean him from oxygen at about I month of age. A chest roentgenogram at 8 months of age showed clear lung fields. The child was alive and asymptomatic at 24 months of age.

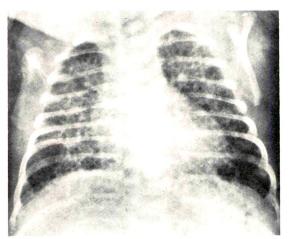


Fig. 10. Case vi. Chest roentgenogram obtained at 1 month of age shows a diffuse lacy infiltration with evenly distributed foci of radiolucency.

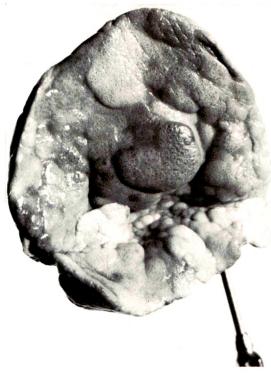


Fig. 11. Case 111. Base of lower lobe inflated to a distending pressure of 35 cm. of water, showing irregular hobnail surface.

#### DISCUSSION

The etiology of this condition remains obscure. The possibility of aspiration of blood with resulting fibrosis was considered in the 4 infants (Cases I, II, III and IV) in whom maternal hemorrhage was present. However, hemorrhage did not occur in the remaining 2 mothers, and hemosiderin was not present in the histologic specimens examined. The aspiration of other irritants remains a possibility, although this is not supported by the roentgenographic or histologic picture.

The monocytic infiltration suggests the possibility of an inflammatory process due to infection. The absence of fever and a characteristic white blood cell response does not rule out infection in a premature infant. However, a consistent organism has not been grown from nasopharyngeal or blood cultures, and extensive bacterial and viral studies carried out by Wilson and Mikity<sup>7</sup>

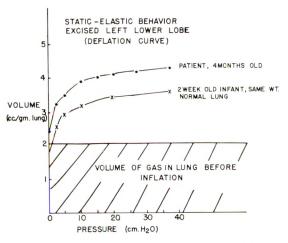


Fig. 12. Volume-pressure characteristics of lobe of Case III compared with that of newborn infant of same weight.

failed to reveal a causative agent.\*

The consistent evidence of hyperaeration on the chest roentgenograms, the measurement of a "normal crying vital capacity" in I infant, and the behavior of an excised lung in another are against a restrictive lung process such as the interstitial fibrosis of Hamman and Rich.<sup>3</sup> The improvement and ultimate recovery in some of these infants would also tend to exclude this condition.

A permanent, congenital, anatomic abnormality would also appear unlikely in view of the clinical and roentgenographic recovery in some of the infants.

It would, therefore, seem most likely that this condition is related to an aberration in pulmonary maturation. In a 400 gm. fetus, the airway is lined with cuboidal epithelium, and the lungs contain a large amount of interductal mesenchyme. In some fetuses of 1,000 gm., alveolar development and pulmonary capillary proliferation are sufficient for adequate oxygenation. 6 Chest

\* Since this report was submitted, BUTTERFIELD et al. (New England J. Med., 1963, 268, 18-21) reported isolation of a non-hemagglutinating Type 19 ECHO virus from the tissues in one fatal case of 4 premature infants who showed a similar roentgenographic pattern. Neutralizing antibodies to that agent were not detected in the infant's serum, his mother's, that of the other infants in the series or of personnel contacts. The causal relationship between this agent and the disease pattern described remains unanswered.

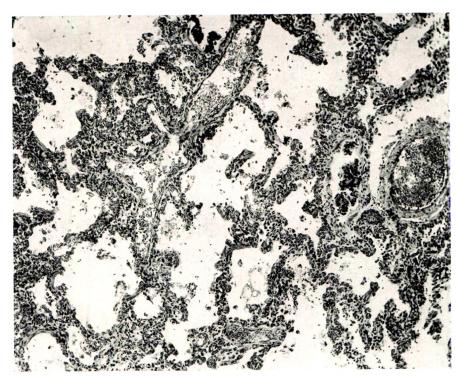


Fig. 13. Case I. Photomicrograph of lung (H & E stain X 100). Note the increased cellularity and septal thickening.

roentgenograms on the first and subsequent days of life in infants of 1,000 gm., or even some of 800 gm. who survive, usually show aerated clear lungs.\* Progressive alveolar development occurs postnatally, both in the premature and full term infants.1,4 Mithal and Emery<sup>5</sup> have suggested, by their method of radial alveolar counts in live and stillborn premature infants, that premature birth is associated with a diminished rate of alveolar proliferation compared with intrauterine development to term. They suggested that the pulmonary changes in the cases of Wilson and Mikity<sup>7</sup> could be the result of diminished alveolar proliferation. Potter6 has also observed immature lungs with some of the alveolar ducts having an almost cyst-like appearance with thick septa in very small infants who survive a few weeks.

We suggest that the term, "pulmonary dysmaturity," might be appropriate to

imply unequal maturation of parts of the lung parenchyma. A failure of alveolar proliferation in random areas could be associated with a lack of distensibility of fibrous septa with normal or even increased distensibility of the available formed air spaces, possibly as a compensatory mechanism. If the pulmonary capillary bed were not fully formed, multiple intrapulmonary shunts might be present, with sufficient venous admixture to cause cyanosis. The improvement in the cyanosis with oxygen therapy suggests that there may be a decrease in the surface area of the lung available for diffusion of gases. It seems probable that both mechanisms are operative. This concept of "dysmaturity" allows for the possibility of ultimate normal anatomic architecture if, in time, all portions of the lung "mature."

The late onset of symptoms in the patients of Wilson and Mikity<sup>7</sup> and in one of ours could be cited as evidence against a developmental abnormality. It is possible

<sup>\*</sup> We have since observed a 400 gm. infant whose chest roent-genograms showed fully distended and clear lungs.



Fig. 14. Case III. Photomicrograph of lung (H & E stain X 100). Specimen fixed at atmospheric pressure after inflation studies. Note the variation in size of the terminal air spaces.

that the diminished pulmonary reserve may have been sufficient for the smaller infants, but became evident with growth and greater activity

There is no way at this time to be certain of the pathogenesis of this condition. It does appear certain that these infants suffered from the same problem, and thus constitute a clinical entity.

#### SUMMARY

Six premature infants seen in 3 institutions have shown pulmonary disease similar to that first described by Wilson and Mikity<sup>7</sup> in 1960.

This condition may be distinguished during life from other causes of respiratory distress by a characteristic roentgenographic picture which consists of a diffuse prominent reticular, lace-like pattern with multiple small cyst-like areas. The outstanding clinical feature is dependence on oxygen to overcome cyanosis. Recovery may take place gradually in the first 6 or

8 months of life, or death may ensue in hours or months.

There have been no characteristic laboratory findings and no common pathogens have been isolated. Postmortem studies suggest an incomplete development of the lung with distention of formed alveolar ducts. Since recovery is possible, the concept of pulmonary dysmaturity is suggested to describe this process.

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We gratefully acknowledge the kindness of Dr. Arthur London of Durham, North Carolina, in permitting us to include his patient (Case VI) in this report. Dr. Gordon Vawter, Department of Pathology, Children's Medical Center, Boston, kindly reviewed the histologic sections and discussed the pathologic findings with us. Dr. H. J. Kauffman, Department of Radiology, Children's Medical Center, Boston, assisted in the collection of the clinical information.

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## PNEUMOCYSTIS CARINII PNEUMONIA\*

#### REPORT OF FOUR CASES

By WILLIAM N. COHEN, M.D., and WILLIAM H. McALISTER, M.D. st. louis, missouri

SINCE first described in this country by Lunseth *et al.*<sup>7</sup> in 1955, pneumocystis Carinii pneumonia has been reported with increasing frequency. In general, cases have been sporadic and have not approached the epidemic proportions described previously in central Europe. It is the purpose of the present authors to report 4 additional, pathologically proven cases seen at our institution and the St. Louis Children's Hospital during the past year.

#### ETIOLOGY

Although the clinical and pathologic entity of interstitial plasma cell pneumonia had been known since the late 1930's, it was not until Vanek and Jirovec's report in 1952 that the organism pneumocystis Carinii, felt by many to be protozoan, was suspected as the etiologic agent. Even though this organism has not been absolutely proven as the cause, its occurrence in large numbers in patients with the characteristic clinical and pathologic state has been repeatedly observed.

#### CLINICAL FEATURES AND PATHOLOGY

The disease primarily affects premature and debilitated infants in the I to 4 month age group. It does occur, however, in older children and adults. The onset of symptoms is often insidious. Respiratory difficulty characterized by increasing respiratory rate and a dusky cyanosis which involves the extremities and perioral region develops initially. This may then progress to a state of marked tachypnea, with subcostal retractions and nasal flaring, and generalized cyanosis. The discrepancy between this picture and the paucity of auscultatory findings in the chest is characteristic. Fever is erratic, but tends to be low-grade. The

white blood cell count is frequently elevated with an eosinophilia of 10 to 15 per cent occasionally noted. The serum calcium has been elevated in some cases.

It is becoming more apparent that there are two main variants of this condition. An epidemic form occurs predominantly in the I to 4 month age group and is seen in Europe; an endemic variety, described in this country, is sporadic and usually found in older children. The former appears when the lowest levels of gammaglobulin are normally noted. Since decreased values are also seen in the endemic group, it has been suggested that this might be a predisposing factor. Therapy with gammaglobulin, however, has not appreciably altered the severity of the symptoms or the over-all course of the disease.

The clinical course is variable, usually lasting from 4 to 6 weeks. Frequently the picture becomes progressively more severe during this time and resists most therapeutic measures except oxygen, mist, and good nursing care. The death rate is estimated at 25 to 40 per cent; but is difficult to evaluate, especially in the nonepidemic form, due to the difficulty in establishing the diagnosis in surviving patients. This can be done, however, with the aid of a complement fixation test prepared from the lungs of fatal cases, or by needle biopsy of the patient's lung. Attempts have been made to identify the organism in the sputum but the yield has been low.5

Grossly, the lungs are heavy and pale gray. Air-containing areas are emphysematous. Microscopically, there is a solid, highly cellular appearance. The interalveolar septa are thickened by the presence of mononuclear cells, most of which are plasma cells and histiocytes. In those cases

<sup>\*</sup> From the Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri.

with hypogammaglobulinemia, however, plasma cells are absent or sparse, as might be expected.<sup>4</sup> The alveolar spaces themselves are filled with hyalin-honeycombed material in which the pneumocystis Carinii organisms are located. They are difficult to identify on the standard hematoxylin and eosin stains and are best seen on smears prepared by silver impregnation.

#### ROENTGEN FEATURES

The roentgen findings, although not specific, are generally quite characteristic of this condition, and when coupled with the clinical picture, can strongly suggest the diagnosis. There may be, however, poor correlation between the severity of symptoms and the roentgenograms.

Initially, there is a perihilar haziness which spreads peripherally and subsequently takes on a granular appearance. These granules then coalesce to form more confluent areas of infiltrate with interspersed radiolucent areas, representing aerated portions of lung which are emphysematous. Feinberg et al.4 describe "halo emphysema" indicating a circular region of emphysema surrounding consolidated portions of lung. The coalescent areas enlarge as more peripheral atelectasis develops. The disease involves all lobes with some relative sparing of the upper lobes and most peripheral portions of the lung fields. The absence of hilar lymphadenopathy or pleural effusion is quite striking. A common type of complication that may develop is interstitial or mediastinal emphysema. In surviving cases gradual resolution occurs. In Falkenbach and co-workers' experience, however, the lungs did not appear completely normal I to 2 years following clinical recovery.

#### REPORT OF CASES

Case I. M.H. was a 3 month old white male initially seen because of failure to thrive. An intravenous pyelogram was interpreted as showing bilateral ureteropelvic obstruction, more marked on the right. A corrective procedure was planned, but deferred due to the presence

of a 38.8°C. fever. On a chest roentgenogram at that time a poorly defined, generalized, granular infiltrate was seen. It was felt that this did not represent the usual bronchopneumonia, but was more likely due to a virus or some unusual organism such as pneumocystis Carinii.

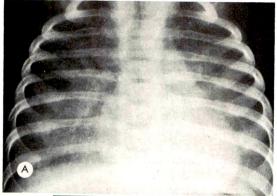
After 3 weeks the patient was afebrile and was re-admitted for laparotomy. A ureteropelvic stricture and aberrant vessel were found, and ureteroplasty was performed. His immediate postoperative course was uneventful and he was discharged improved.

Four days later he was re-admitted with a history of progressive respiratory distress and tachypnea. He was cyanotic about his extremities and perioral region but his chest was clear to percussion and auscultation. During the ensuing days his respiratory rate varied from 40 to 78 per minute and the pulse rose as high as 156 per minute. Although the white blood cell count was 22,000 per cubic mm. he remained afebrile. The total serum proteins were 3.41 gm. per 100 ml. with an albumin of 2.73 gm. and a globulin of .68 gm. The gammaglobulin was .17 gm., falling from a previous level of .73 gm. 4 weeks earlier. This was originally obtained because the child's older brother was known to have hypogammaglobulinemia.

The patient was treated with oxygen and mist with some initial relief of his cyanosis. Despite the administration of continuous oxygen at high concentration, he developed a persistent generalized dusky-gray color. His clinical deterioration was not influenced by multiple antibiotics. In an attempt to make a diagnosis, a lung biopsy was performed which resulted in a pneumothorax, requiring treatment with a chest tube. The patient died 2 days later, 5 weeks after his initial admission.

Chest roentgenograms obtained during his terminal admission showed marked progression of a bilateral granular infiltrate involving all lobes (Fig. 1, A and B). At autopsy the lungs were nearly airless and pneumocystis Carinii was identified. The interalveolar septa contained lymphocytes and mononuclear cells. No plasma cells were present.

Case II. A.N. was a white female who at 5 months of age developed ptosis of her right eye. Shortly thereafter, a left mandibular swelling, ptosis of the left eye, and hepatosplenomegaly were noted. Widespread destruction of the skull and facial bones was seen on roentgenograms. A



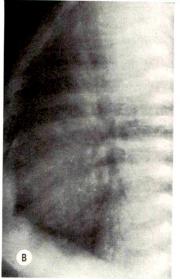


Fig. 1. Case 1. (A) Posteroanterior and (B) lateral roentgenograms. A granular infiltrate involves all lobes with confluence in the lower lobes.

biopsy of the mandibular mass was reported as undifferentiated carcinoma. The patient was placed on cytoxan and received radiation therapy to the involved areas of her head. Moderate regression of the soft tissue masses as well as healing of the areas of bone destruction resulted.

At 9 months of age, she was seen because of a 2 week history of coughing and sneezing accompanied by rhinorrhea plus several episodes of cyanosis and dyspnea. The patient was in moderate respiratory distress demonstrating a dusky peripheral and perioral cyanosis, a tachypnea in the range of 60 per minute, and some subcostal retracting. Fine bilateral rales were heard. Recurrent masses had developed beneath her eyes.

She was admitted to the hospital, during

which time her respiratory rate rose to 80 and her pulse rate reached 170 per minute. The temperature varied from 37°C. to 39.3°C. The admission hemoglobin was 9.4 gm. with a white blood cell count of 4,900 per cubic mm., containing 9 per cent eosinophils. Protein determinations were not obtained. An intravenous pyelogram was interpreted as showing inferior displacement of the left kidney by a faintly calcified suprarenal mass. The underlying neoplastic disease was then felt to most likely represent a metastatic neuroblastoma.

Despite supportive care with oxygen, penicillin, streptomycin, and erythromycin, the patient's respiratory distress and cyanosis progressed. She expired on the eighth hospital day.

On chest roentgenograms bilateral nodular infiltrates involving all lobes were noted, with subsequent development of areas of coalescence and localized emphysema (Fig. 2, A and B). At postmortem examination, widely disseminated neuroblastoma plus pneumocystis Carinii pneumonia was reported. There were no plasma cells present in the interalveolar septa.

Case III. J.K. was a white male who was first seen at the age of 2 months because of a persistent eczematoid eruption beginning on the scalp, but ultimately involving the groin and flexor creases of the extremities. By 7 months of age cervical lymphadenopathy, bilateral chronic otitis media, and hepatosplenomegaly had developed. Punched-out lesions were seen on skull roentgenograms obtained at that time. A cervical lymph node biopsy was performed and a clinicopathologic diagnosis of Letterer-Siwe's disease was made. The hemoglobin was 6.1 gm. with a white blood cell count of 14,000 per cubic mm. Fever spikes to 40°C. were recorded. The sedimentation rate was 10 and the total serum protein was 4.65 gm. per 100 ml., with an albumin of 3.64 gm. and a globulin of 1.01 gm.

The patient was treated with prednisone (20 mg. per day) plus cytoxan. After several months the lymphadenopathy, dermatitis and aural discharge had regressed considerably.

At 20 months of age he was admitted to the hospital with lethargy, anorexia, and rapid respirations. His chest was clear to percussion and auscultation, although mild subcostal retractions were noted. There was no cyanosis. The temperature was 38.2°C. with an initial respiratory rate of 76 rising to 100 per minute, and the pulse rate reaching 180 per minute. The

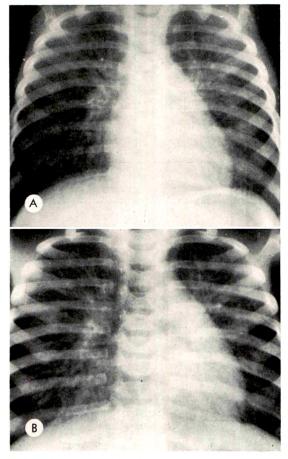


Fig. 2. Case II. (A) Posteroanterior chest roentgenogram. A coarse nodular infiltrate fans out from each hilar area. (B) A repeat roentgenogram 5 days later demonstrates some coalescence of the infiltrates and localized emphysema.

hemoglobin varied from 9 to 12.5 gm., and the white blood cell count from 5,000 to 16,000 per cubic mm. with normal eosinophils. At this time his total serum proteins were 5.12 gm. per 100 ml. with albumin being 3.66 gm. and the globulin 1.46 gm. A gammaglobulin level of .21 gm. was also obtained.

On a chest roentgenogram a fine disseminated granular infiltrate was seen (Fig. 3) and interpreted as being consistent with either miliary tuberculosis, reticuloendotheliosis, or pneumocystis Carinii pneumonia. Cultures were negative. Multiple antibiotics including staphcillin, chloromycetin, and INH were of little benefit. There was a decrease in the respiratory rate, however, after the administration of gammaglobulin; but this was transient. Due to the possibility of the pulmonary problem being due to

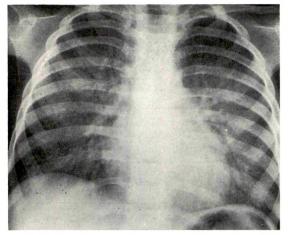


Fig. 3. Case III. Posteroanterior chest roentgenogram. A fine granular infiltrate is present throughout both lung fields.

reticuloendothelial involvement, 25 r was administered to each lung field.

Twelve days after admission his clinical condition had stabilized sufficiently for the patient to be discharged. Nine days later, however, he was re-admitted because of increasing tachypnea. This continued to progress despite all measures, and the patient expired after an episode of apnea 4 weeks after his initial admission.

Autopsy findings showed Letterer-Siwe's disease with involvement of the skin, vertebral bodies, thymus and spleen. The lungs were consolidated and contained pneumocystis Carinii in the alveolar spaces. Macrophages and fibroblasts were present in the interalveolar septa, but no plasma cells.

Case IV. S.H. was a 6 month old white male who had a brassy cough since 2 months of age.

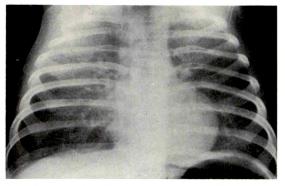


Fig. 4. Case IV. Posteroanterior chest roentgenogram. Coarse granular infiltrates involve all lobes.

TABLE I

	Age, Race and Sex	Associated disease	Respiratory rate per min.	Pulse per min.	Temperature °C.	White blood cell count per cubic mm.	Time of death after onset of respiratory symptoms
Case I M.H.	4 mo. WM	Failure to thrive; ureteropelvic ob- struction	40- 78	90-156	37 -37.8	22,000	5 wk.
Case II A.N.	9 mo. WF	Neuroblastoma	40- 80	90-170	37 -39.3	4,900	3 wk.
Case III J.K.	20 mo. WM	Letterer-Siwe's disease	76-100	96–180	38.2-37.6	5,000-16,000	4 wk.
Case IV S.H.	6 mo. WM	Eczema and milk allergy	60-100	90-120	38	8,000	3 wk.

During this period he had eczema and an apparent milk allergy which was relieved by substitution with Mullsoy. For the week prior to admission to the hospital, the cough became more severe and was accompanied by spasmodic choking episodes. There was a mild temperature elevation to 38°C. He was initially seen at another hospital, and, because of the unusual roentgen findings of widely disseminated infiltrates, he was referred to the St. Louis Children's Hospital.

On physical examination there was an eczematoid dermatitis. The chest was clear to percussion and auscultation although the respiratory rate was 62 per minute. By the second hospital day, however, it rose to 100 with a pulse of 120 per minute. The hemoglobin was 13.5 gm., the white blood cell count 8,000 per cubic mm., and the total serum protein 4.93 gm. per 100 ml. with the albumin 2.62 gm. and globulin 2.31 gm. The gammaglobulin was .39 gm.

The patient's condition deteriorated rapidly without apparent benefit from antibiotics and supportive care. He died after 2 weeks of hospitalization. Follow-up chest examination demonstrated progression of the disease (Fig. 4). The pneumocystis Carinii organism was identified in the patient's lungs at autopsy. The interalveolar septa contained mostly unidentifiable mononuclear cells. Occasional plasma cells were present.

#### DISCUSSION AND DIFFERENTIAL DIAGNOSIS

The diagnosis of pneumocystis Carinii was suspected ante mortem on the basis of

characteristic roentgen findings and the clinical picture in each of the patients presented. They conformed to the endemic type in that all the patients were over 4 months of age and had a severe associated debilitating condition with the possible exception of Case IV. In Cases I and III hypogammaglobulinemia was documented and was familial in the former. It is noteworthy that some relief of respiratory distress was obtained after administration of gammaglobulin in Case III, although it was temporary and had no influence on the ultimate outcome.

The pertinent clinical findings in these cases are summarized in Table 1. Table 11 is a correlation of serum protein levels and the histopathology of the interalveolar septa in regard to the presence of plasma cells.

The roentgen findings in our cases were in agreement with those described by Falkenbach *et al.*<sup>3</sup> and others.<sup>4</sup> There were bilateral, fine, granular infiltrates which involved all lobes with notable absence of hilar lymphadenopathy and effusion. Serial examinations showed coalescence of the infiltrates with interspersed areas of emphysema. Relative sparing of the periphery of the lung field was observed, and 2 of the patients showed relative sparing of the upper lobes, although in Falkenbach's larger series of over 100 cases, a tendency

TABLE II

	Serum Protein Determinations (gm. per 100 ml.)			Pathology of Interalveolar Septa fo	
	Albumin	Globulin	Gamma- globulin	Presence of Plasma Cells	
Case 1 Normal values for age	2.73 3.67	.68 1.81	.17	Mononuclear cells and lymphocytes; no identifiable plasma cells	
Case II	(No serum protein determinations made)			No plasma cells	
Case III Normal values for age	3.66 4·34	1.46 2.75	.21	Macrophages and fibroblasts; no plasma	
Case IV Normal values for age	2.62 4.06	2.3I 2.15	·39 ·39	Mostly unidentifiable mononuclear cells occasional plasma cells present	

toward greater involvement of the apices was noted.

In the differential roentgen diagnosis, pulmonary edema of noncardiac origin, viral pneumonias including cytomegalic inclusion disease and rubeola, collagen diseases, and reticuloendothelioses should be considered. Granulomatous diseases, such as early miliary tuberculosis or pneumonitis from fungi, may present a similar roentgen picture. Disseminated bacterial bronchopneumonia, aspiration pneumonia, and hydrocarbon pneumonia are more likely to resemble the later stage of this entity after coalescence of the infiltrates has begun.

Clinical and laboratory data will help exclude many of the above conditions from differential consideration. This problem may be further resolved as serial chest roentgenograms are obtained.

#### SUMMARY

Four cases of pneumocystis Carinii pneumonia are presented. The patients were 4 to 20 months in age. In each instance the organism was identified at postmortem examination. Associated diseases included failure to thrive secondary to renal obstruction, metastatic neuroblastoma, Letterer-Siwe's disease, and eczema. Abnormally low levels of gammaglobulin were demonstrated in 2 cases.

The diagnosis was suggested ante mortem

in all instances. This was based on the correlation of characteristic roentgen manifestations with the clinical picture.

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## CONGENITAL DEFECT OF GASTRIC MUSCLE\*

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CONGENITAL defect of the gastric muscle is a rare condition consisting of thinning or absence of the muscular coat in one or more areas of the stomach with a tendency to perforate early in the neonatal period. Once perforation has occurred, death follows rapidly if prompt surgical repair is not performed. The condition has been described in pediatric and pathologic literature, but we have not been able to find any reports in the radiologic literature. The purpose of this communication is to alert the radiologist who may be in a position to aid in the early recognition of this pediatric emergency.

#### REVIEW OF LITERATURE

In 1943, Herbut<sup>6</sup> reported the sixteenth case of perforation of the stomach in a newborn infant, which was the first case reported in which gastric rupture occurred because of congenital absence of part of the muscle layers of the gastric wall. The patient was a 5 day old Negro boy who had a history of vomiting of greenish-yellow material and of abdominal distention for one day. The infant died a few hours after admission. At autopsy the entire muscle of the anterior gastric wall was absent over an elliptic area measuring 3.5 by 6 cm. At both the proximal and distal ends, the merging bands of muscle united in the form of a V. In this area there was an irregular rupture about 4.5 cm. long. Two smaller defects of the muscle layer measuring 0.3×0.6 cm. and 0.4 × 0.4 cm. were found on the posterior gastric wall.

Potter<sup>10</sup> observed rupture of the stomach in newborn infants fed by gavage, the site of perforation being frequently the greater curvature of the stomach in the region most susceptible to damage from the introduction of a gavage tube. She also reported 1 instance of defective formation of the muscle layer of the stomach. The infant died of peritonitis following gastric rupture. The muscle coats were described as becoming gradually thinner and disappeared at the margin of the tear in the wall of the stomach.

In 1954, Braunstein<sup>2</sup> reviewed 8 cases from the literature and presented 5 new cases, 4 of which were demonstrated at autopsy, 1 on surgical exploration. There was cyanosis, respiratory difficulty, abdominal distention and vomiting in most of the patients. Free air was reported in the peritoneal cavity in 6 out of the 13 cases. Most of the perforations occurred near the greater curvature and the majority near the cardia. In most cases there was absence of the muscle layer in a segment 3 to 7 mm. around the perforation. In others there was thinning and disappearance of the muscularis at the edge of the defect.

It is of interest that respiratory distress and cyanosis may precede abdominal distention. These signs are presumably due to aspiration. Watery discharge from the nose and mouth occurs as frequently as regurgitation of gastric contents.

Four of Braunstein's patients succumbed 1, 2, 6 and 36 hours after the onset of symptoms. In the single case repaired, exploration was performed only a few hours after onset. Prematurity may shorten the period of survival. Five of the 13 cases Braunstein<sup>2</sup> reviewed weighed less than 2,500 gm. at birth.

Several other authors<sup>4,7,8</sup> have reported

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observations on spontaneous rupture of the stomach apparently associated with congenital defect of the gastric muscle. In the radiologic literature Caffey³ mentions that in a small percentage of cases developmental defects in the intestinal wall may be responsible for pneumoperitoneum, and Miller³ states that perforation of the stomach in the newborn is generally due to a congenital defect in the gastric muscle.

## ROENTGEN SIGNS OF PNEUMOPERITONEUM IN THE NEWBORN

Astley¹ described a central translucency in the supine roentgenogram in infants with pneumoperitoneum. Miller³ referred to this as the "air dome" or the "football" and believed it to be pathognomonic of pneumoperitoneum. Braunstein² noted that the falciform ligament of the liver divides the cephalad portion of this radiolucent shadow. Occasionally, the caudal half is divided by a similar streak, representing the urachus (the plica umbilicalis media).8

The most important roentgenogram is with the patient in the upright position in which even a very small amount of air will be detected under the diaphragm, whereas large amounts tend to surround the liver and separate it from the right hemidiaphragm.<sup>12</sup> MacGillivray *et al.*<sup>7</sup> noted gas in the scrotum when the infant was inverted. This occurs in infants because the air may dilate the cavity of the open processus vaginalis, which normally closes about the sixth month of life.<sup>3</sup>

Pneumoperitoneum can also be demonstrated in a lateral recumbent position with the roentgenogram taken with a horizontal beam. The lateral roentgenogram with the patient supine may show a similar translucency anteriorly separating the abdominal viscera from the anterior abdominal wall.<sup>9</sup>

During the past 6 years we have observed 3 patients with neonatal gastric perforation associated with congenital defect of the gastric muscle. Two of these patients died 4 and 16 hours after surgery, while I was repaired and was doing well I month later.

#### REPORT OF CASES

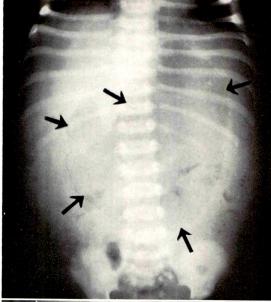
CASE I. A premature Negro male infant weighing 5 lb., 5 oz. (2,400 gm.) was delivered by cesarean section because of a prolapsed umbilical cord. The course was uneventful until the fifth day when abdominal distention was noted. An upright roentgenogram of the abdomen showed a large amount of free air under both diaphragmatic shadows and an air-fluid level in the abdomen. Under local anesthesia the abdomen was opened and a large amount of purulent peritoneal fluid was noted. High along the greater curvature of the stomach a perforation 5.0 cm. in length was found and closed. The gastric muscle layer appeared deficient around the perforation. Small fragments of tissue were sent to the department of pathology which reported absence of the muscle wall of the stomach and acute peritonitis. The patient died 16 hours after surgery.

Case II. This white male infant weighed 6 lb.,  $3\frac{1}{2}$  oz. (2,800 gm.) following a normal delivery. At 5 days of age the child became cyanotic, deeply jaundiced, had numerous watery, green stools and intermittent apnea. He appeared moribund on admission. The lungs were clear to auscultation; the abdomen was distended and no bowel sounds were heard. An upright roentgenogram of the abdomen revealed free air under the diaphragm. A diagnosis of perforated abdominal viscus was made.

Upon opening the peritoneal cavity a large amount of foul smelling milk was found. A perforation was noted in the middle of the posterior wall of the stomach. This was surrounded by a large area of necrosis and a sleeve resection of the stomach was performed. Because of trauma involving the spleen, this organ was excised. The patient expired 4 hours after surgery.

The pathology report on the portion of the stomach removed showed pronounced mucosal hemorrhage with overgrowth of bacteria and hypha elements on the serosa and muscularis. One section of the stomach had all layers present but in one area the muscle layer was absent. In this area the gastric wall was composed of mucosa, submucosa, muscularis mucosae, and serosa.

Case III. A Negro male infant had a normal delivery at term. He did well until the sixth day when he developed abdominal distention and a nonreducible right inguinal hernia. On admission to the hospital on the seventh day of life,



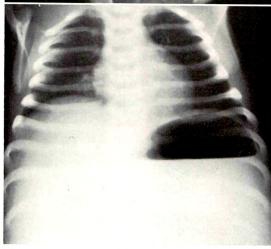


Fig. 1. Upper: Supine roentgenogram retouched to show gas-distended stomach and duodenal bulb. Note scattered gas through remainder of intestinal tract. Lower: Upright roentgenogram showing large gas-fluid level in second portion of duodenum. This was probably taken immediately prior to gastric perforation which was successfully closed at surgery.

physical examination revealed clear lungs, abdominal distention, a necrotic and edematous umbilicus and right inguinal hernia. Supine and upright roentgenograms (Fig. 1) of the abdomen revealed a pronounced distention of the stomach with a large air-fluid level and a smaller air-fluid level in the second portion of

the duodenum. No free air was noted under the diaphragm. Scattered gas shadows were seen throughout the remainder of the intestinal tract. A diagnosis of obstruction of the second portion of the duodenum was made.

Within a few hours after admission surgical exploration revealed a large perforation in the anterior wall of the stomach. The surrounding gastric wall appeared deficient in the muscle layer. The gastric perforation was closed and the patient was returned to the ward in good condition. The small fragments of tissue submitted for microscopic examination revealed gastric tissue showing acute inflammation and hemorrhage with deficiency in the muscle layer.

The patient continued to do well and was discharged 7 days later in excellent condition. A clinic note I month later indicated that the child was doing well.

Comment. It is probable that gastric perforation occurred in Case III after the roentgenograms of the abdomen were made. Thus closure of the gastric wall was performed very soon after perforation in this infant who was born at full term, these factors probably being responsible for recovery.

#### DISCUSSION

During the past 6 years there have been 6 patients with neonatal gastric perforation; in 3 instances this was associated with a congenital defect of the gastric muscle. The other three patients included: (1) a newborn Negro female infant with meconium ileus, jejunal stenosis, malrotation and perforation of the greater curvature of the stomach; (2) a premature Negro female infant with duodenal atresia and perforation of the greater curvature of the stomach; and (3) a Negro female infant delivered by cesarean section, with early respiratory difficulty and perforation of a prepyloric gastric ulcer 48 hours after birth.

Other authors have reported that gastric perforation in the newborn is caused by gastric ulceration and obstruction at the pylorus or in the duodenum.<sup>7,11</sup>

Gastric perforation in the neonatal period is uniformly fatal unless the condition

is recognized early and surgical repair is promptly performed. When respiratory symptoms occur early in the neonatal period, the infant should be closely observed for signs of vomiting, diarrhea and abdominal distention. Besides obtaining a roentgenogram of the chest, supine and upright roentgenograms of the abdomen are very important. When the stomach is distended relatively more than the remainder of the gastrointestinal tract and free air is noted, perforation of the stomach or duodenum should be suspected.

#### SUMMARY AND CONCLUSIONS

Three patients with neonatal gastric perforation associated with a congenital defect of the gastric muscle layer have been reported.

Gastric perforation in the neonatal period is uniformly fatal unless recognized and repaired early.

Supine and upright roentgenograms of the abdomen are indicated in infants with respiratory distress and abdominal distention.

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We are grateful to Dr. Rowena Spencer of the Department of Surgery, Louisiana State University School of Medicine, for supplying clinical data on the cases reported.

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## HYPERTROPHIC PYLORIC STENOSIS

## A BRIEF REVIEW AND A REPORT IN PREMATURE TWINS

By H. J. WILLIAMS, M.D. ST. PAUL, MINNESOTA

THE occurrence of hypertrophic pyloric stenosis in both members of a twin birth is uncommon. It is even more unusual when the twins are premature. Such a recent occurrence prompts this report and a brief review of the disease, with particular emphasis on the features pertaining to its occurrence in twins.

The first case of pyloric stenosis was reported 175 years ago by Beardsley<sup>2</sup> in the earliest volume of Medical Transactions issued in this country. McKechnie<sup>9</sup> reported the disease in one member of a set of twins in 1913 and Redlin<sup>15</sup> was the first to report the disease in both members of a twin birth in 1923.

#### ETIOLOGY AND INCIDENCE

Many causative theories have been advanced, but none has had universal acceptance. The occasional presence of the disease in premature infants and stillbirths<sup>6</sup> supports a congenital origin.

Wallgren<sup>18</sup> roentgenologically examined the stomachs of 1,000 consecutive Swedish male infants during the newborn period and found no abnormality in any. All were subsequently followed and by 6 weeks of age, 5 had developed clinical and roentgenologic findings of hypertrophic pyloric stenosis, correlating closely with the suspected incidence of 1 per 150 in Swedish male infants. Meuwissen and Sloof<sup>13</sup> reported an operation upon a  $2\frac{1}{2}$  week old child in whom they felt "the pylorus was perhaps a little thicker than normal." Reoperation 35 days later because of recurrent symptoms disclosed a very large tumor. These findings indicate that the muscular hypertrophy, if present at birth, is seldom sufficient to produce symptoms or characteristic roentgen findings and that postnatal factors, possibly including the mechanical irritation of milk curds, gradually result in

the production of the typical clinical and roentgenologic manifestations of the disease.

Hypertrophic pyloric stenosis occurs more frequently in males than in females, 85 per cent being males in the large series of Ladd and associates. No racial predisposition has been demonstrated.

The increased incidence in firstborn infants has been stressed and confirmed by McKeown *et al.*<sup>10</sup> in a study of 1,059 cases treated at Birmingham Children's Hospital. However, Delprat and Pfleuger<sup>4</sup> stated in 1948 that the average American family has 1.5 children and that 66 per cent are thus normally firstborn. On this basis they concluded that hypertrophic pyloric stenosis is not primarily a disease of the newborn. Miller and Friesen<sup>14</sup> in their series found the disease more often in secondborn than firstborn infants.

Prematurity does not increase the incidence of pyloric stenosis and Wilson<sup>19</sup> found only 5 cases in 3,813 premature infants (expected incidence, 3–4 per 1,000). Approximately 4.5 per cent of cases of pyloric stenosis occur in premature infants.

An increased incidence in breast fed babies, as commonly reported, was not found in the University of Kansas series where only 5 per cent were entirely breast fed, 33 per cent were both breast and bottle fed, and 61 per cent were formula fed. Polyhydramnios, which is commonly associated with atresia of the esophagus and upper small bowel, is seldom seen in pyloric stenosis, a factor against a congenital origin. The incidence is 20 times as great in siblings of an affected individual as in the population as a whole. 11

#### PATHOLOGY

In specimens examined prior to 7 to 10 days of age, the mucosa and submucosa are

normal and the only changes are in the muscularis which shows hypertrophy of the circular smooth fibers as well as an actual hyperplasia. Later, mucosal edema becomes prominent with resultant narrowing of the pyloric channel, which in turn stimulates further compensatory muscular hyperplasia. On gross section, the well-developed tumor is frequently olive-shaped with a cartilaginous consistency and the narrowed elongated pyloric canal is almost occluded by edematous mucosal folds. The hypertrophic muscular segment characteristically is tapered on the gastric side but terminates abruptly on the duodenal side of the pyloric canal.5 On microscopic section, the hyperplastic, hypertrophic muscularis is edematous and infiltrated with a few leukocytes, as are the mucosa and submucosa to a lesser degree.

#### SYMPTOMS

Vomiting is the chief symptom and occurs in all patients. Benson and Warden,3 in an analysis of 707 cases, found that the average age of onset of vomiting was 3 weeks but in 27 patients it began immediately after birth. Serial roentgenograms show a close correlation between the progression of the pyloric narrowing and the symptoms. Initially, with minimal narrowing of the pyloric channel, only regurgitation or occasional vomiting occurs, but, as the hypertrophy increases, the vomiting becomes persistent and often forceful in nature. Projectile vomiting is usually present, but not uncommonly the projectile aspect is absent. Dependence upon this symptom may delay the diagnosis and in one of our recent cases, with the most pronounced roentgen and surgical findings, the clinical impression was chalasia. The vomitus is typically free of bile, a distinguishing feature in differentiating this disease from duodenal stenosis, duodenal band, and malrotation. Occasionally, the vomitus contains small amounts of blood.

While vomiting is the chief symptom, constipation, failure to gain weight satisfactorily, and decreased urine output sec-

ondary to dehydration are also noted. With increasing physician awareness of the disease and the more health-conscious attitudes of today's parents, it is most unusual to find a markedly emaciated, dehydrated, in extremis infant as frequently pictured in the older textbooks.

In premature infants the disease presents a deceptively milder picture than in full-term infants. The vomiting is frequently intermittent (often with 2 to 5 days respite), nonprojectile, and often temporarily responsive to medical treatment. In addition, the gastric peristaltic waves are usually less pronounced.

#### SIGNS

The presence of an abdominal mass is the most important physical feature and is observed in 76 per cent of the cases according to Akin and Forbes. The mass is usually present in the right upper quadrant, but occasionally it is felt in the midline or even to the left of the midline.

Prominent upper abdominal peristaltic waves are visible in approximately 75 per cent of the patients and they can best be seen following a feeding.

Dehydration and weight loss are often apparent on physical examination and are proportional to the severity and duration of the vomiting. In severe cases lethargy results from marked fluid and electrolyte losses.

Associated congenital anomalies are seldom found in hypertrophic pyloric stenosis according to Akin and Forbes, lessening the likelihood of a strong congenital etiologic factor, since congenital anomalies are frequently multiple.

#### ROENTGEN FINDINGS

Since the symptoms may be atypical and the mass often unpalpable, roentgenologic examination prior to surgery is worthwhile. It will disprove some "typical" clinical cases, confirm many suspected cases, and uncover others without the classic signs and symptoms. The majority of infants with this condition receive the benefit of



Fig. 1. Roentgenogram showing good demonstration of the persistent lesser curvature peristaltic wave just proximal to the markedly narrowed and elongated pyloric canal. Vomiting was intermittent and nonprojectile. The clinical diagnosis was chalasia.

roentgenologic examination in our community. I am impressed with the frequent difficulty in palpating the tumor, even with the full bias of knowing its presence and exact site by means of fluoroscopy.

The typical roentgen findings of hypertrophic pyloric stenosis have been adequately described. The elongated narrow pyloric canal, topped by the duodenal cap the base of which is indented by the muscular tumor, resembles a mushroom with a curved stalk or an open umbrella with a bent handle. The diagnosis can confidently be made only after visualization of the narrow, elongated pyloric channel (Fig. 1); such indirect signs as air distention of the stomach, absence of intestinal gas, and delayed gastric emptying are in themselves unreliable. The stomach may or may not be dilated and the peristaltic waves may be decreased, normal, or exaggerated. With large tumors, relatively high grade obstruction results and there may be considerable delay in visualizing the pyloric canal. For this reason fluoroscopy should be intermittent rather than continuous. Often before the entire canal itself is visualized, the peristaltic waves force a small amount of medium into the narrowed proximal channel, the so-called "beaking" phase. It may take a few or many subsequent waves for the contrast material to pass beyond the beaking state and to fill the entire canal.

A frequent, and to my knowledge, undescribed observation that enables the radiologist to predict pyloric stenosis during the first few peristaltic waves, even before the narrowed channel is visualized, is worthy of mention. In the presence of pyloric obstruction, the terminal portion of each peristaltic wave persists as a hump on the lesser curvature of the stomach adjacent to the pyloric canal for several seconds, as if reluctant to depart and admit failure in its ability to empty the gastric contents. This finding can be appreciated both on fluoroscopy and roentgenograms, but particularly the former.

During the past 18 months, 44 cases have been diagnosed roentgenologically at the St. Paul Children's Hospital and all were subsequently confirmed surgically. Approximately 50 cc. of a solution composed of equal parts of water and oral water-soluble opaque medium is injected through an opaque esophageal catheter following preliminary aspiration of the gastric contents via the catheter. Aspiration of the stomach contents prevents dilution of the medium, allowing clearer visualization of the narrowed pyloric segment. In addition, the presence of a thick curdled milk type of aspirate offers a preliminary clue to the diagnosis frequently. The water-soluble media have several advantages over barium. An important one is their ready miscibility with any residual gastric content and absence of formation of a precipitate as frequently occurs with barium. Their lesser hazard in the event of aspiration secondary to vomiting is also a distinct advantage. In addition, because of their lesser viscosity, they leave the normal stomach much more rapidly than barium, allowing a definitive diagnosis to be made sooner and with less radiation exposure to the infant. So rapidly do these media leave the normal infant stomach that the absence of cap filling

within 2 minutes following administration is strong presumptive evidence for hypertrophic pyloric stenosis. It is preferable and imperative, however, to actually visualize the elongated pyloric channel in each case rather than to rely on secondary findings if surgery is contemplated. To date, no serious complications have occurred using the newer media in any of our cases, although several infants developed a mild transient diarrhea, presumably due to the hypertonicity of the solution.

#### OCCURRENCE IN TWINS

Laubscher and Smith, in 1947, conclusively disproved a previously accepted twofold increase in frequency in twins and proved that the incidence in twins is equal to that in the general population. Metrakos,12 in 1953, found 125 pairs of twins with hypertrophic pyloric stenosis reported in the world literature and added 5 new pairs. Of these 132 pairs of twins with the disease, both twins were reported to be affected in 49 instances. Because of a lack of surgical or autopsy proof in 4 cases, the total remaining cases in which both twins had proven pyloric stenosis was 45. Subsequent cases where both twins have developed pyloric stenosis have been reported by Wait, 17 McDermott, 8 and Sterling et al. 16 By using strict criteria for monozygosity, Metrakos<sup>12</sup> demonstrated that both twins were affected in 66.7 per cent of monozygous pairs and in only 3.49 per cent of dizygotic pairs. It is easy to explain concordance in dizygous twins because of the previously noted twenty-fold increase in siblings of an affected individual. However, the discordance in monozygotic twins is more difficult to explain. In 33.3 per cent of the monozygous twins, only one twin was affected, while the genetically identical twin with the same antenatal history was unaffected. The increased incidence of occurrence in both twins in the monozygous pairs as compared to the dizygous pairs would indicate a hereditary factor. The lack of involvement of one twin in one-third of

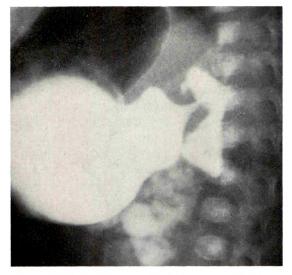


Fig. 2. R.M.(1). Elongated pyloric canal. Note persistence of peristaltic wave on lesser curvature of prepyloric region.

the pairs of identical twins may be due to an environmental factor effective in only one of the gentically identical twins.

#### REPORT OF CASE IN TWINS

Premature twin male infants, presumably monozygous but not so conclusively proven, were born to a primiparous mother on September 11, 1961 (EDC November 11, 1961) after an uneventful pregnancy. R.M. (1) weighed 3 lb. at birth as did R.M. (2).

R.M. (1) (Fig. 2) was admitted to Children's Hospital on September 30, 1961, having vomited most feedings since birth. The vomiting at first was not projectile but later became so. A I cm. diameter mass was palpable slightly above and to the right of the umbilicus. The laboratory findings were noncontributory except for a hemoglobin of 10.8 gm. and a blood urea nitrogen of 49 mg./100 cc. Stomach examination on October 2, 1961 revealed pyloric stenosis and a patulous esophagogastric junction. A chest roentgenogram demonstrated patchy pneumonitis in the right upper lobe, considered secondary to aspiration. Because of generally poor condition, medical therapy including gastric drip and antispasmodics was begun, but vomiting continued. A repeat stomach examination on October 9, 1961 again demonstrated pyloric stenosis, and there now was moderate gastric dilatation. A Ramstedt operation was per-



Fig. 3. R.M. (2). Elongated pyloric canal. Persistent prepyloric lesser curvature peristaltic wave present. Regurgitation into esophagus from patulous esophago-gastric orifice.

formed on October 10, 1961 under local anesthesia. Subsequent oral feedings were retained but the baby suddenly developed dyspnea 24 hours later and died. Autopsy revealed cerebral edema and pulmonary atelectasis, but the site of the surgical procedure was intact.

R.M. (2) (Fig. 3) was admitted at the same time as R.M. (1). He could retain very small feedings but would vomit any feedings over 22 cc. The vomiting was not projectile. The laboratory findings were not unusual. A stomach examination on October 3, 1961 revealed a lesser degree of pyloric stenosis than in the other twin and a patulous esophagogastric junction with ready reflux. The vomiting increased under medical treatment and a Ramstedt procedure was performed under local anesthesia on October 11, 1961. The postoperative course was smooth and he was discharged on November 25, 1961, weighing 5 lb.,  $3\frac{1}{2}$  oz. and tolerating feedings well. He was re-admitted on December 7, 1961 with symptoms of loose stools for 4 days and fecal vomiting for 12 hours. An abdominal roentgenogram showed a mechanical small bowel obstruction. An operation was performed a few hours after admission and a 2 inch segment of ileum was found incarcerated in a small

right inguinal hernia. The postoperative course was stormy and the patient died the next day. No autopsy was permitted.

#### SUMMARY

- 1. A brief review of the etiology, incidence, pathology, clinical features, and roentgen findings of hypertrophic pyloric stenosis is given with special emphasis on the occurrence in twins.
- 2. An additional occurrence in both members of a twin birth is reported.
- 3. A helpful but seldom appreciated roentgenologic sign is described.
- 4. The advantages of the water-soluble opaque media in the diagnosis of this disease are presented.

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# ROENTGEN DIAGNOSIS OF COMPLICATIONS OF CYSTIC FIBROSIS\*

By ARTHUR S. TUCKER, M.D., LEROY W. MATTHEWS, M.D., and CARL F. DOERSHUK CLEVELAND, OHIO

CYSTIC fibrosis affects many systems in the human body; the respiratory system is involved probably without exception. The classic roentgen picture of the chest is shown in Figure 1, A and B.

#### RESPIRATORY FINDINGS

Pulmonary emphysema is invariably a feature. This is apt to be much more evident clinically than roentgenographically, but can always be found on scrutinizing a series of roentgenograms made of a patient over a period of time. The lateral view is frequently more revealing in this respect than the frontal, even after therapy has

been instituted. An extreme example is shown in Figure 2, A and B. The patient was a boy of 10 weeks, admitted to the hospital with diarrhea and bronchiolitis. He did not respond to therapy, but developed pneumonia (Fig. 3, A and B) and expired.

It is important to recognize that the cause of emphysema may be cystic fibrosis so that the patient may be adequately managed in order to avoid irreversible lung damage due to repeated episodes of pulmonary infection. Figure 4, A, B and C shows a boy who experienced wheezing since the age of 3 weeks, and cough and large pasty stools since the age of 5 months.

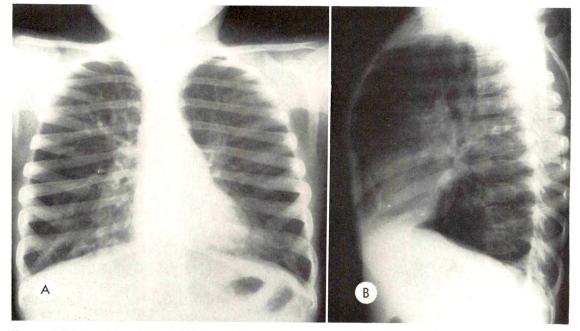


Fig. 1. (A) Posteroanterior and (B) lateral chest roentgenograms of a white female, aged 5 years, show evidence of pulmonary emphysema, with considerable parenchymal streakings, and of impairment of alveolar pneumatization. The anteroposterior diameter of the thorax is increased above normal, the sternum is bulging, the clavicles are elevated, and the diaphragm is flattened.

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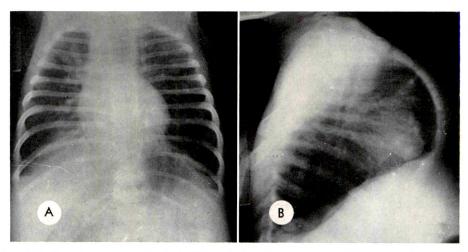


Fig. 2. (A and B) Roentgenograms of a male child who had had diarrhea since the age of 1 month, admitted at 10 weeks with "bronchiolitis." The lungs are markedly overdistended, the anteroposterior thoracic diameter much increased.

Figure 4 A is a chest roentgenogram made at the age of 1 year, when he was hospitalized for "bronchopneumonia" and had his adenoids removed. At the age of 8 he was treated for "asthma" with continuous desensitization. A sweat test showed a chloride level of 119 mEq./L. By this time his height and weight were less than the third

percentile for his age. Subsequent roentgenograms showed the ravages wrought by the constant low-grade respiratory infections he suffered.

Emphysema has been rather severe in patients who have survived to maturity. Figure 5, A and B shows the chest of a 22 year old patient. Occasionally, there is

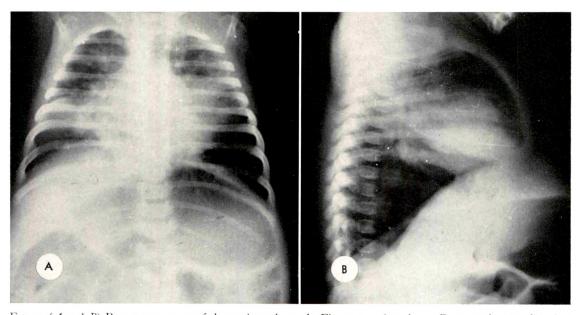


Fig. 3. (A and B) Roentgenograms of the patient shown in Figure 2, 4 days later. Pneumonic consolidation has appeared in both lungs. Emphysema is still a very prominent feature. The child succumbed 4 days after these roentgenograms were made.

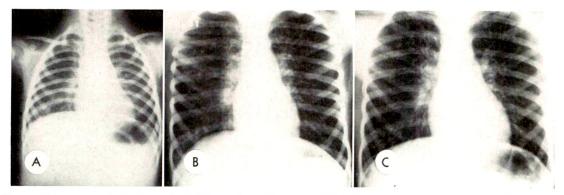


Fig. 4. Roentgenograms of a male child at (A) 1, (B) 10 and (C) 12½ years. A was made at the time of adenoidectomy, performed for wheezing and cough which he had had since the age of 3 weeks. The boy was treated with continuous desensitization for asthma until the age of 8, when a sweat test revealed an elevated chloride level of 119 mEq./L. When aggressive respiratory management was initiated at the age of 10 (B) he was very small, below the third percentile in height and weight. Two and a half years later (C) he had gained weight, and the pulmonary infection was improved.

rupture of an emphysematous area of lung which produces pneumothorax (Fig. 6, A and B).

Pulmonary infection may be caused by one or more of the human respiratory pathogens. *Staphylococcus aureus* is the commonest infecting agent, frequently coagulase positive and penicillin-resistant.

Figure 7, A and B shows a boy who, when he first entered our clinic, did not exhibit particularly advanced disease, but the pneumonia was found to be due to Friedländer's bacillus and he responded very slowly to therapy. Although roentgenograms reveal that the lungs have cleared, throat cultures show that he continually

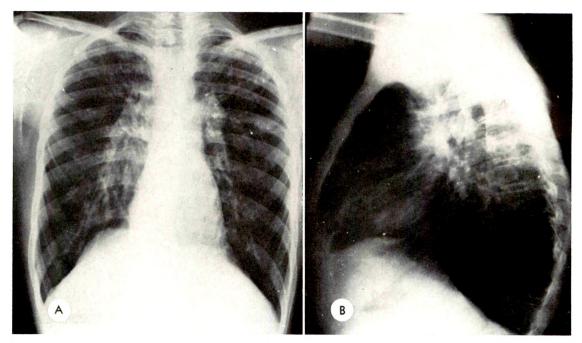


Fig. 5. (A and B) Survival into maturity. Chest roentgenograms of a male, aged 22 years, with severe emphysema and limited pulmonary function.

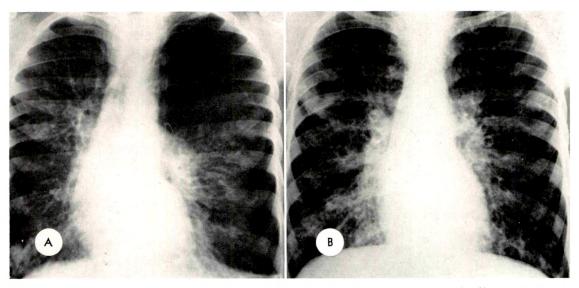


Fig. 6. (A) Pneumothorax in a 12½ year old male with severe respiratory involvement by fibrocystic disease A thoracotomy tube was inserted, with water-seal suction, and a subsequent roentgenogram (B) shows no further air in the pleural cavity.

harbors Pseudomonas. Proteus is an organism found frequently in cultures of patients who have been treated with antibiotics for staphylococcal disease. *Aerobacter*, *Escherichia coli*, and *Monilia* may also be encountered.

Pulmonary infection in patients with cystic fibrosis, as in those with tuberculosis,

sometimes seems to show a predilection for the upper lobes (Fig. 8). Infection, when uncontrolled, of course permits the formation of lung abscesses. Figure 9, A and Bshows a girl who was treated vigorously, but could not be cured of extensive focal infections and died. On our regimen of antibiotics we rarely see the pneumatoceles

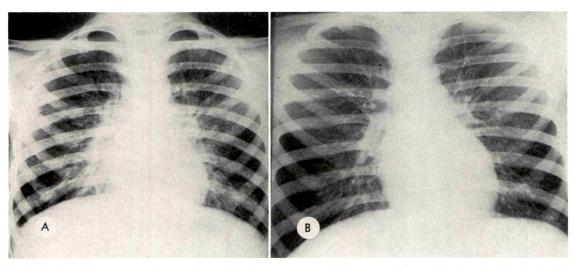


Fig. 7. (A) Chest roentgenogram made when the patient was  $5\frac{1}{2}$  years old and was first seen with a bronchopneumonia. Cultures grew Friedländer's bacillus. Response to treatment was slow, but a follow-up at 9 years of age (B) shows very little pulmonary abnormality other than emphysema. Throat cultures, however, persistently grew Pseudomonas.

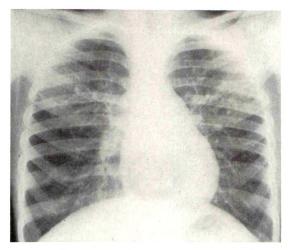


Fig. 8. Chest roentgenogram of a 7 year old girl shows more fibrosis and infection in the upper than in the lower lung fields.

which formerly occurred with pulmonary infection due to *Staphylococcus aureus* and other organisms (Fig. 10, A, B and C).

Atelectasis is still a fairly frequent complication in the disease (Fig. 11, A and B; and 12, A and B). Unless the plug of secretions filling the lumen of the bronchus can

be removed by postural drainage, penetrating vaporized medication, or instrumentation, atelectasis may become irreversible (Fig. 13, A and B). In such instances bronchiectasis is destined to ensue.

Portions of the respiratory tract other than the lungs also may be affected. Figure 14, A, B and C shows the sinuses of a girl who has always had extensive sinusitis. Another frequent complication in the upper respiratory tract is the development of nasal polyps (Fig. 15, A and B).

#### EXTRARESPIRATORY FINDINGS

Allied to respiratory symptomatology in patients with cystic fibrosis is involvement of the skeleton. Retardation of skeletal maturation and growth is frequent. Hypertrophic pulmonary osteo-arthropathy has been reported but is rare. More common is clubbing of the fingers and toes which develops in association with limited respiratory capacity and cor pulmonale (Fig. 16).

The biliary system may show alteration of secretions in the same manner as the

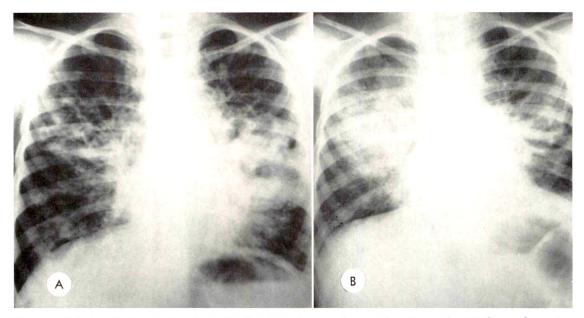


Fig. 9. (A) Chest roentgenogram of a cystic fibrosis patient at  $4\frac{1}{2}$  years shows necrosis and abscess formation to have destroyed so much of the lung parenchyma as to preclude normal pulmonary function. (B) In spite of vigorous antibiotic therapy for  $1\frac{1}{2}$  years, the pulmonary infections spread. Nine days after B, the patient died.

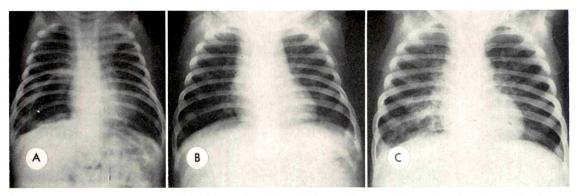


Fig. 10. Chest roentgenograms of a white male child at (A) 3, (B) 9 and (C) 15 months of age. Cough was noted commencing at the age of 5 weeks. (A) At 3 months the patient was infected with Staphylococcus pneumonia which produced a large pneumatocele. (B) He recovered, and the lungs cleared. (C) Six months later, however, he had further pulmonary infection and died.

respiratory tract. When such is the case, biliary cirrhosis results, followed by portal hypertension and formation of esophageal varices from the resulting collateral circulation. Two patients thus afflicted, among our 175 living patients with cystic fibrosis, have had such severe hemorrhage from varices as to necessitate portocaval shunting.

Except for varices, the upper gastrointestinal tract of cystic fibrosis patients is almost free of roentgenographically demonstrable disease. Neuhauser<sup>2</sup> has reported calcification of the pancreas. At least 90 per cent of the patients have disturbed digestive processes of greater or lesser degree, which for the most part produce few specific roentgen findings. Frequently, however, there is gaseous distention of the bowel (Fig. 17, A and B) and in some instances a disordered motor pattern (Fig. 18). In 1 of our patients, a marantic 3

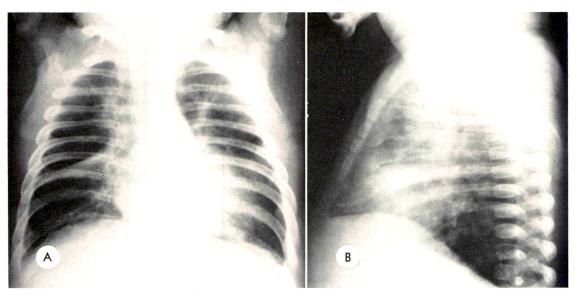


Fig. 11. (A) Posteroanterior and (B) lateral roentgenograms of a boy with acute pulmonary infection show rather typical findings of bronchiolitis with right middle lobe atelectasis.

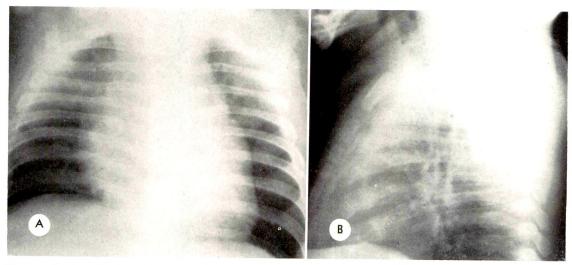


Fig. 12. (A and B) Same patient as shown in Figure 11, 2 months later. The lungs had largely cleared; a minimal density persists from residual infection in the right upper lung.

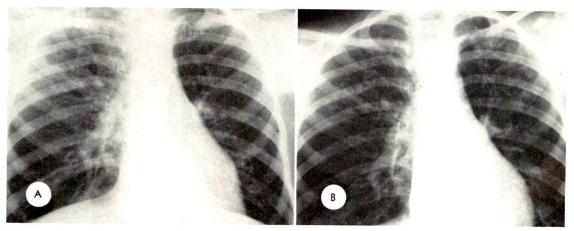


Fig. 13. Chest roentgenograms of a boy with chronic and repeated respiratory infections. (A) When first seen at 13 years of age, there was at electasis of the left lower lobe visible behind the heart. (B) A year later, in spite of intensive effort directed to the respiratory passages, the atelectasis was unchanged.

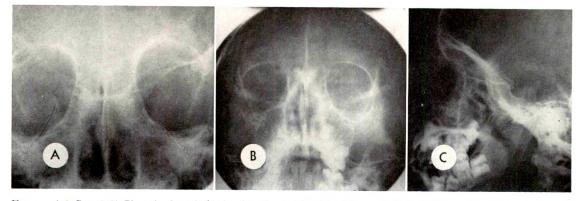


Fig. 14. (A, B and C) Chronic sinus infection in a 6 year old girl with cystic fibrosis. The adenoids are enlarged.

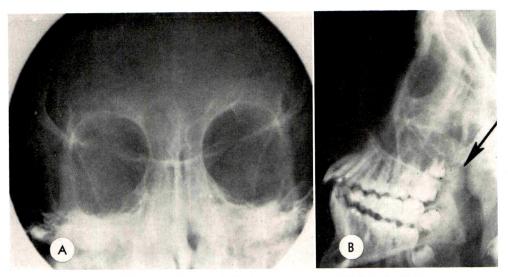


Fig. 15. (A and B) Chronic sinus infection in a 14 year old boy. In B the arrow points to a polypoid growth in the posterior nasal passage.

month old baby girl, a pneumoperitoneum occurred (Fig. 19, A and B) which at laparotomy was found to be due to perforation of an ulcer of the first part of the duodenum. The patient did poorly postoperatively, and died 10 days later. Autopsy revealed severe cystic fibrosis of the pancreas. Pneumatosis intestinalis, it has been reported, may in some instances occur in cystic fibrosis.

The bulky fat-laden intestinal mass which enters the large bowel of cystic fibrosis patients may produce a rather characteristic pattern in the colon (Fig. 20). Glazer has reported a series of such patients in whom the coarse mucosal pattern was apparently the result of contact with the large foamy mass of feces which was present. The patient shown in Figure 20 presented the rather frequent complaint in cases of cystic fibrosis; namely, rectal prolapse. Another patient similarly afflicted gave a history of intussusception at the age of 15 which was suggested on barium enema study performed elsewhere and confirmed at laparotomy.

A conspicuous exception to the generalization about the lack of pathognomonic gastrointestinal findings occurs in some newborn infants with intestinal obstruction. These babies are born with markedly distended abdomens, which may elevate the diaphragm sufficiently to embarrass the respiratory process. No meconium passes, and the rectum is empty. When roentgenograms of the abdomen show dilated loops of bowel and small bubbles of air in strings along the lumina, a specific diagnosis of meconium ileus can be made (Fig. 21, A and B). Furthermore, it can be predicted with seeming certainty that the child, if he survives the initial obstruction, will at a



Fig. 16. Hands of the patient whose chest is shown in Figure 6. The fingers show severe clubbing. The patient was cyanotic and considerably limited in respiratory capacity.

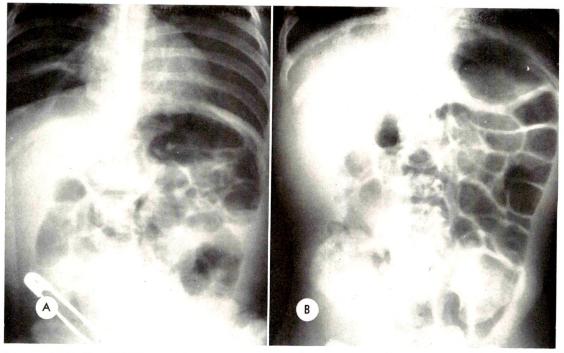


Fig. 17. (A) Sitting and (B) recumbent roentgenograms of a very malnourished 5 month old male who had a large protuberant abdomen. Much gas is present in both small and large intestine. Note atelectasis of the middle lobe of the right lung in A. Following vigorous therapy directed at management of the respiratory and digestive systems, the boy gained rapidly from below the 3rd to the 90th percentile in height and weight.



Fig. 18. The small intestine of an 8 year old male patient with cystic fibrosis shows considerable clumping of barium from the abnormal digestive juices. The boy also developed cirrhosis of the liver, and 5 years later had sufficient bleeding from esophageal varices to necessitate a portocaval shunt.

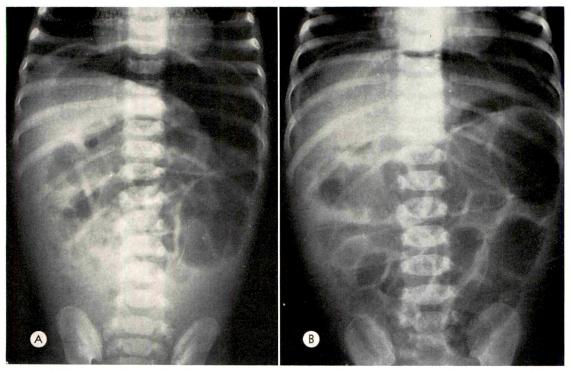
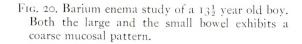


Fig. 19. (A) Erect and (B) supine abdominal roentgenograms of a 3 month old marantic female show free intraperitoneal air. The abdomen was exceedingly protuberant, the limbs markedly wasted. Exploratory laparotomy showed a perforated ulcer of the first portion of the duodenum, which was plicated. The patient died 10 days postoperatively. Autopsy revealed a severe degree of pancreatic fibrosis.





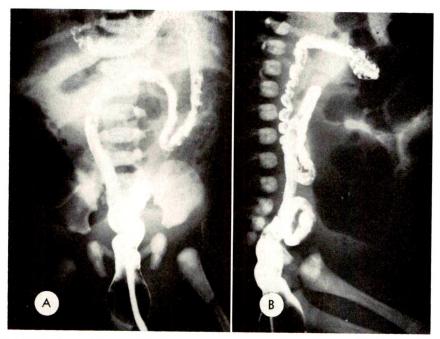


Fig. 21. (A and B) Barium enema studies of a newborn white male who had a markedly distended abdomen. The small bubbles of air in the small intestine are characteristically found in meconium ileus. The colon is of small caliber, having never had fecal matter pass through it.



Fig. 22. A protuberant abdomen in a female 15 hours old who had been vomiting. The small bowel is markedly distended. Radiolucent bubbles in the left upper quadrant are due to air trapped in viscid meconium. Laparotomy showed intestinal dilatation to mid-ileum, with plugging by meconium at this point. The occlusion was bypassed by an intestinal anastomosis, and the patient was discharged from the hospital after 1 month.

later date manifest other symptoms of cystic fibrosis.

A patient with a similar picture came to us in 1947, before we were aware of this etiologic relationship. The child was operated upon for intestinal obstruction at the age of 18 hours, and a side-to-side anastomosis was carried out in the ileum. She recovered from the operation, but subsequently developed wheezing and noisy respirations. At the age of 6 months, a duodenal aspiration showed no pancreatic enzyme activity. Two years later she was seen with a severe case of subcutaneous emphysema which apparently resulted from perforation of a lung bleb without pneumothorax. Within a short time she died a "thermal death" because of insulation by the subcutaneous air and inability of the sweat glands in the skin to function (Fig. 22, 23 and 24).

### CONCLUSION

Cystic fibrosis causes pulmonary emphysema, upon which may be superimposed infection, pneumothorax, or atelectasis.

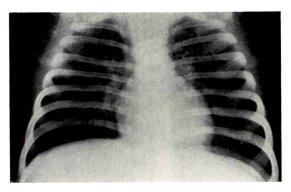


Fig. 23. Chest roentgenogram of patient shown in Figure 22 at the age of 7 months shows only mild pulmonary emphysema. Much wheezing and noisy respiration were present. Aspiration of duodenal juice showed no pancreatic enzymes.

The sinuses are frequently infected, and polyps may develop in the nasal passages.

Biliary involvement leads to cirrhosis and portal obstruction. The lack of pancreatic enzymes results in characteristic stools which produce a coarse mucosal pattern in the colon. Meconium ileus produces a typical gas pattern in the abdomen of newborn infants.

The roentgen appearance of these varied complications of cystic fibrosis has been presented to call attention to the protean manifestations of the disease. Radiologists who encounter such conditions may be able to suggest the possibility of the underlying etiology, so that the exact diagnosis may be made. Proper management may then be

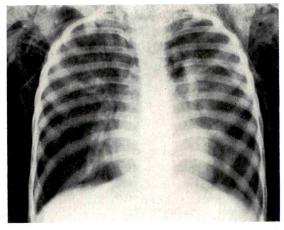


Fig. 24. Chest roentgenogram of patient shown in Figures 22 and 23 at 2 years and 9 months of age when she was admitted following 13 days of difficult respirations. She was in acute respiratory distress, with moderate cyanosis and a swollen, spongy face and trunk. The roentgenogram shows a severe subcutaneous emphysema. She died the following day.

instituted before the patient becomes crippled by irreversible disease.

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### ERASEROPHAGIA

By J. L. CURRY, M.D., and W. J. HOWLAND, M.D. WHEELING, WEST VIRGINIA

ROENTGEN identification of ingested foreign bodies is of interest and may occasionally be of considerable clinical importance. Ingestion of foreign substances such as earth can produce readily recognized roentgenographic findings.<sup>1</sup>

We recently observed an abdominal roentgenogram of an 8 year old female showing numerous discrete opacities which were widely scattered throughout the colon (Fig. 1). There was no history of ingestion of radiopaque medication, but close questioning finally elicited a history of "nib-

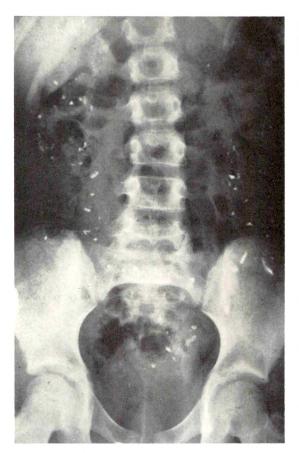


Fig. 1. Roentgenogram of an 8 year old female showing numerous opacities scattered throughout the colon.

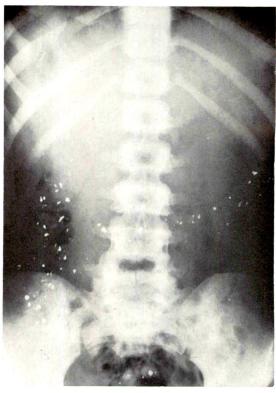


Fig. 2. Roentgenogram of a 12 year old male showing opaque colonic opacities quite similar to those seen in Figure 1.

bling" on erasers in school. The eraser in question was procured and roentgenograms were taken which showed that it was highly radiopaque.

Within a short time after this, identical findings were encountered in another roent-genogram of the abdomen of a 12 year old male child (Fig. 2). Again, questioning elicited a similar history. In neither of these cases were there symptoms referable to the gastrointestinal tract, and the opacities disappeared within 24 hours.

These observations prompted us to investigate the composition of abrasive erasers, which we found to vary remarkably from one manufacturer to another.<sup>2–5</sup>

Some contain as much as 50 per cent lithopone (70 per cent barium sulfate and 30 per cent zinc sulfide) and calcium carbonate. Many manufacturers do not include lithopone or other materials of high roentgen density in their products (Fig. 3).

Deliberate ingestion of eraser fragments by ourselves easily reproduced our initial observations (Fig. 4), but only with erasers of high roentgen density and with special reference to lithopone content.

#### SUMMARY

Eraserophagia, ingestion of abrasive ink or pencil eraser fragments, is probably a rather common habit, particularly among school children. These eraser fragments, in

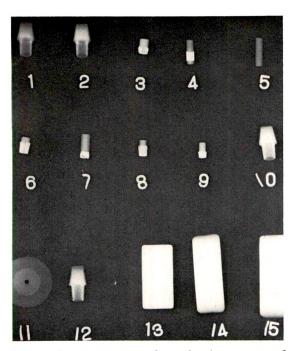


Fig. 3. Roentgenogram of 15 abrasive erasers of widely varying composition and representing the products of 10 different manufacturers.

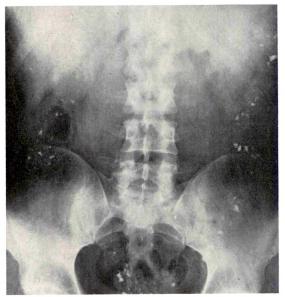


Fig. 4. Roentgenogram of one of us (WJH) 15 hours after deliberate ingestion of several grams of opaque eraser fragments.

some instances, are intensely radiopaque and produce typical roentgenographic features on roentgenograms of the abdomen.

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# GIANT HEMANGIOMA IN INFANCY WITH SEC-ONDARY THROMBOCYTOPENIC PURPURA\*

By HAROLD L. ATKINS, M.D., JAMES A. WOLFF, M.D., and ANNELIESE SITARZ, M.D. NEW YORK, NEW YORK

IN 1940 Kasabach and Merritt<sup>8</sup> of the Columbia-Presbyterian Medical Center published the first report of giant hemangioma associated with a thrombocytopenic state. Since that report, a number of additional cases, 4 of which proved fatal, have been recorded in the literature. <sup>1-6,9-16</sup> Because there exists no uniformity of opinion concerning etiologic factors or modes of therapy, it was felt worthwhile to report 2 additional cases of this syndrome.

#### REPORT OF CASES

Case 1. J.S. (#251655) was admitted to Babies Hospital, Columbia-Presbyterian Medical Center on October 24, 1955 at the age of 14 days because of extension of a "blood birthmark" of the right buttock. The infant, a Eurasian female, was delivered at another hospital by low forceps with vertex presentation after induction 20 days before the mother's expected delivery of the child, for unknown reasons. The birth weight was 6 lb., 3 oz. On the second day of life, a birthmark was first noted on the skin of the right buttock measuring about 4.5×7 cm. It gradually enlarged over the next 3 days to 10×12 cm. and was then stable. The infant ate poorly while in the hospital and was given vitamin K.

Discharge from the nursery was on the fifth day of life, but the patient was admitted to the same hospital at 12 days of age because of the further extension of the birthmark to both buttocks, perineum and lower anterior adbominal wall. Laboratory data were as follows: hemoglobin 7.4 gm. per cent, white blood cell count 13,000/mm.³ with a normal differential, platelets 70,000/mm.³, prolonged prothrombin time, normal venous clotting time, and prolonged bleeding. The fibrinogen index showed no clotting. After a transfusion of 100 cc. whole blood, the hemoglobin was 7.9 gm. per cent, the prothrombin time normal and the fibrinogen index indicated no clotting.

The patient was transferred to the Babies Hospital 2 days later. On physical examination, she was a well-developed, well-nourished female in no acute distress. The skin of the chest wall was tense and displayed 2+ pitting edema. An intense purple discoloration extended down from the level of the second lumbar vertebra to cover the buttocks, lower abdomen, perineum and the thighs (Fig. 1,  $\mathcal{A}$  and  $\mathcal{B}$ ). There was 3+ pitting edema of both lower extremities. The remainder of the physical examination was noncontributory.

On admission to Babies Hospital, the hemoglobin was 5.5 gm. per cent and the platelets 10,000/mm.<sup>3</sup>. During the next 8 days, the patient received 7 transfusions of fresh whole blood, with little resultant improvement in the hemoglobin level, due to continued hemorrhage.

Radiation therapy was instituted on the second day after admission. The factors were 120 kv. peak, 5 ma., 20 cm. target skin distance, and a half value layer of 5 mm. Al. A total air dose of 400 r was delivered in 100 r daily increments between October 26, 1955 and October 29, 1955 through an oval 11 $\times$ 9 cm. portal to the left buttock with no observable response. A second course of 400 r air dose was delivered from November 5, 1955 to November 7, 1955 with the same factors and portal size. At the start of the second course of irradiation, the hemoglobin began to rise toward normal levels despite no further transfusions. The hemangioma began to regress immediately following the second course of irradiation and improvement occurred with cessation of bleeding despite an insignificant rise of the platelets to the range of 24,000–28,000/mm.<sup>3</sup>.

The patient was discharged on December 3, 1955 and followed in the out-patient clinic. The hemoglobin dropped to 5.8 on December 30, 1955 but rose spontaneously to 11.1 by February 24, 1956. Platelets rose to 79,000/mm.³ by that date but again dropped to 40,000/mm.³ by April 20, 1956 without evidence of any bleeding tendency.

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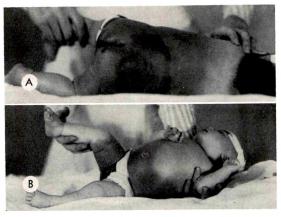


Fig. 1. Case I. (A and B) Appearance of patient on admission to Babies Hospital. The very dark area on the back is the extent of the original hemangioma and the lighter gray area marks the extension coincident with the onset of the bleeding tendency.

The hemangioma was noted to be slightly larger on April 3, 1956, with some purpuric spots about the lesion but none elsewhere. A single dose of 400 r in air was delivered to the hemangioma and it gradually receded. One month later the platelet count was 119,000/mm.³. By July 13, 1956 only a flat scar persisted and the platelets were 188,000/mm.³. The patient was last seen on October 25, 1960 at the age of 4 years. The platelet count was 227,000/mm.³ and an atrophic scar was noted over the site of the previous hemangioma. No growth de-

fects were observed. The patient's clinical course is shown diagrammatically in Figure 2.

CASE II. M.H. (#150-79-85), a white female, was admitted to the Babies Hospital on December 31, 1960 at the age of 8 months because of a hemangioma of the left flank and a bleeding tendency of 1½ weeks' duration. Six weeks prior to admission, two bruised areas of the left flank, associated with an upper respiratory infection, were noted by the mother but all signs and symptoms cleared in 2 days. One and one-half weeks before admission, a large spider-like reddish area was noted on the left flank and the patient was admitted to another hospital. An intravenous pyelogram showed that both ureters were deviated to the midline, with greater displacement on the left. The patient was discharged without treatment on December 24, 1960 but readmitted on December 26, 1960 with enlargement of the ecchymotic area. A bluish flank mass, 8 × 4.5 cm., was noted on the left with a central firm portion fixed to the underlying tissues. Also noted on admission were bleeding gums and old petechiae on the extremities. Laboratory data showed a hemoglobin of 7.7 gm. per cent and a platelet count of 60,000-90,000/mm.3.

The impression on admission was hemangioendothelioma and the patient was put on intravenous hydrocortisone and then 5 mg. prednisone three times daily, with some reduction of

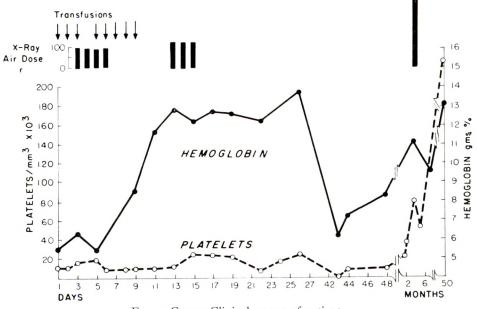


Fig. 2. Case I. Clinical course of patient.

petechiae. A transfusion of 150 cc. whole blood was given. A biopsy of the left flank on December 29, 1960 was interpreted as organizing hematoma of subcutaneous tissues but a later review showed capillary hemangioma. The biopsy site continued to ooze blood, the patient's condition deteriorated and she was transferred to Babies Hospital on December 31, 1960.

On admission to Babies Hospital, the patient appeared to be a well-developed and well-nourished white female infant in acute distress due to bleeding. The abdominal dressings were soaked with blood and active oozing was apparent from sutures at the biopsy site in the left flank.

Ecchymoses were seen covering the back, abdomen and the venipuncture site on the right side of the neck. The abdomen was distended and the liver was enlarged two finger breadths below the right costal margin. Extensive pitting edema of the lower half of the body was noted.

The hematocrit was 33 per cent and the platelets 24,000/mm.<sup>3</sup>. The patient was catheterized and intravenous fluids were administered via a cut-down. Therapy consisted of 600 mg. of chloramphenicol and 25 mg. of hydrocortisone every 8 hours administered intravenously, while 3,000,000 units of penicillin were given intramuscularly. A transfusion of 125 cc. fresh whole blood was given on admission and numerous subsequent transfusions were given on following days.

An intravenous pyelogram showed moderate caliectasis on the left due to a mass in the flank. A review of the slides from the other hospital resulted in a diagnosis of capillary hemangioma.

Radiation therapy was instituted on January 9, 1961. Since the marked amount of ecchymosis obscured the original lesion, generous 8×10 cm. anteroposterior opposing fields were directed to the left flank. The treatment factors were 250 kv. peak, 15 ma., 50 cm. target skin distance, half value layer 1.5 mm. Cu. A calculated midline dose of 458 r was delivered in 4 days. A sudden marked improvement began on January 13, 1961, the last treatment date, with a diuresis and cessation of bleeding despite no improvement in the platelet count which at its lowest was 8,000/mm.³. No further transfusions were required.

An intravenous pyelogram on January 26, 1961 showed marked improvement and the patient was discharged on January 28, 1961 with a

hemoglobin of 12.8 gm. per cent and a platelet count of 10,000/mm.<sup>3</sup>. All medication had been discontinued.

The patient was followed at home. On February 2, 1961, petechiae of the legs were again noted and the platelets were 45,000/mm.<sup>3</sup>. By February 11, 1961, the hemangioma had grown to 7×13 cm. and an additional 100 r was given, resulting in a reduction in size of the hemangioma. One month later, an additional 100 r was given because of increase in size and 50 r was given in April, 1961.

On June 28, 1961, the area of induration about the left flank was 15×10 cm. with a few petechiae about it. The platelet count was 19,000/mm.³ and the hemoglobin 10.7 gm. per cent. On October 28, 1961, the petechiae were no longer present and the hemangioma was no longer visible despite no further therapy. The platelet count was 110,000/mm.³ at this time, over 9 months after her original course of radiation therapy, and increased to 160,000/mm.³ by 16 months after initial treatment (Fig. 3).

#### DISCUSSION

The syndrome of thrombocytopenic purpura associated with large hemangiomas in children has now been firmly established as a clinical entity. Whereas the ordinary capillary or cavernous hemangioma of childhood is benign and will usually undergo regression spontaneously or with a minimum of therapy, the situation may become desperate when complicated by a platelet deficiency and its associated bleeding tendency. Four cases reported in the literature have ended fatally.3,5,6,13 One of these died of sepsis 5 months after splenectomy6 and another appears to have had a malignant variety of hemangioendothelioma, as evidenced by multiple recurrences and widespread involvement in a slightly older than usual patient.3

The relation of the thrombocytopenia to the hemangioma is not clearly understood. It is possible that the two conditions are coincidental and enlargement of the hemangioma is noted because hemorrhage within it readily occurs in the platelet deficient state. The immunologic factors which may give rise to thrombocytopenic purpura are extensively covered by Harrington *et al.*<sup>7</sup> They have postulated a role of the spleen in

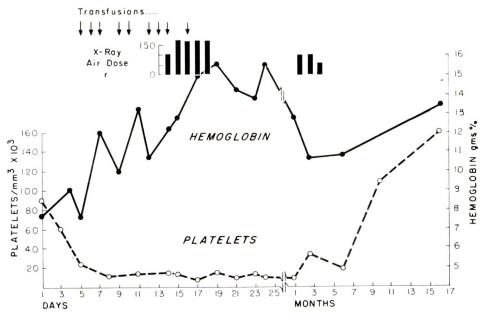


Fig. 3. Case II. Clinical course of patient.

removing sensitized platelets as well as in the possible production of some humoral factors causing platelet agglutination or suppressing platelet formation. The spleen has been irradiated without an improvement. In our Case II, the spleen was probably incidentally irradiated but we do not ascribe clinical improvement to the splenic irradiation. Surgical attack by splenectomy has been credited with clinical remission, 1,10 although other authors 6,16 felt it was not beneficial.

It is most likely that thrombocytopenia results from formation of platelet thrombi within the hemangioma<sup>6,12</sup> in an attempt at repair of multiple capillary defects and this may indeed be the mode of healing of hemangiomas.<sup>16</sup> Most hemangiomas are of such a size that the process does not result in thrombocytopenia. Only the larger lesions may sequestrate platelets to such an extent as to cause a bleeding tendency.

Since platelet determinations are not performed routinely for the ordinary type of childhood hemangioma in most hospitals, we do not know if any of these patients may have thrombocytopenia without purpuric manifestations. At the Combined Pediatric Tumor Clinic of the Babies Hospital, plate-

let counts have been performed on many infants and children with hemangiomas without bleeding tendencies. Thrombocytopenia has not been found except in the presented 2 cases, and one reported by Kasabach and Merritt.8 Certainly, purpura need not accompany thrombocytopenia as noted by the clinical improvement despite low platelet levels following radiation therapy in our 2 cases as well as the relatively sustained low platelet levels in the cases reported by Rhodes and Borrelli.11 Platelet counts increased rapidly following radiation therapy in the cases reported by Scherz et al., 12 Southard et al., 14 and Kasabach and Merritt,8 but the radiation doses were rather high. Platelet counts remained low for some time despite splenectomy in cases reported by Good et al.6 and Bogin and Thurmond.1 The rapid response of the bleeding tendency to radiation in small doses without change in platelet levels for many months following irradiation remains unexplained.

The attitude toward treatment of infantile hemangiomas at the Combined Pediatric Tumor Clinic of Babies Hospital is conservative. Ordinarily, only those lesions are treated which may interfere with func-

tion such as compression of the esophagus or trachea and retro-orbital hemangiomas which may produce exophthalmos, or hemangiomas which may be subject to trauma and infection, such as about the lip or rectum. These are usually treated with small doses of radiation (150–300 r) and then observed at monthly intervals. Retreatment is rare. Even in the cases in this report with purpuric manifestations, small radiation doses appear to have been effective in bringing about clinical remission. Late growth disturbances are unlikely with these small doses.

In a late follow-up of the patient reported by Kasabach and Merritt, roentgenograms revealed changes consistent with radiation-induced growth disturbance in the pelvis and hip as well as an osteochondroma of the proximal left femur 11 years after moderately intensive roentgen ray and radium therapy for a hemangioma of the thigh. High radiation doses were also reported by Southard *et al.*<sup>14</sup> and Scherz *et al.*<sup>12</sup> It is ordinarily unnecessary to use such large amounts of radiation and the clinical status of the patient rather than platelet counts should be used as an index of efficacy of treatment.

#### SUMMARY AND CONCLUSIONS

Two additional case reports of thrombocytopenic purpura and giant hemangioma are presented. Both patients had a good clinical response to radiation therapy with cessation of purpuric manifestations, despite maintained depression of platelet counts for several months after completion of treatment. Although it is likely that platelet sequestration occurs within the hemangioma, the clinical improvement following irradiation without immediate increase in circulating platelets remains unexplained.

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# LATE EFFECTS OF ROENTGEN THERAPY GIVEN IN INFANCY\*

By BRIAN O'MALLEY, M.B., GIULIO J. D'ANGIO, M.D., and GORDON F. VAWTER, M.D. BOSTON, MASSACHUSETTS

ROENTGEN therapy is an effective means of treating childhood cancer, but often unavoidably involves the irradiation of normal tissues undergoing growth and development. The implications of radiation injury in children are graver than in the mature adult, for successful treatment is attended by a life expectancy measured in decades, rather than in years. In the child, relatively small doses can lead to serious functional and anatomic disturbances. Some of these, such as retardation of bone growth, may be manifest within months, while others may not appear until many years have elapsed. Such sequelae as radiation nephritis may have a long latent period, develop insidiously, and be confused with an unrelated condition. Another and allied problem is oncogenesis, which may supervene many years after roentgen therapy of children, as has been re-emphasized recently in relation to bone tumors.2 These manifold expressions of late radiation damage are exemplified in the extraordinary patient whose initial clinical course was first described by Wyatt and Farber<sup>27</sup> in 1941, and whose subsequent life was equally noteworthy.

#### REPORT OF A CASE

A.B. This white female infant was the product of a normal delivery, but had cyanotic spells immediately after birth. Radiation therapy was administered in 3 seances to the region of the thymus, which was thought to be enlarged and the cause of respiratory embarrassment. The details regarding the treatment administered are not available, but the technique in use at that particular hospital during this era was as follows: 200 kv. peak, 0.5 mm. Cu and I

mm. Al (added filter), 50 cm. target skin distance. Air doses of 50 r were given on alternate days to the anterior chest. The cyanosis cleared thereafter.

She was first seen at the age of 3 months at The Children's Hospital Medical Center in September, 1938, because of pallor, apathy, anorexia, and failure to gain weight. Physical examination revealed a pale, undernourished infant weighing 8 lb., 8 oz. The abdomen was distended, and an enlarged nodular liver was felt 6 cm. below the right costal margin. It extended across the abdomen to the left upper quadrant. Laboratory investigations revealed no significant findings. Roentgenographic studies showed no evidence of skeletal metastases. There was displacement of the intestinal gas pattern by the enlarged liver.

Laparotomy and liver biopsy were performed on November 14, 1938. At operation the liver was described as being enlarged. On its surface were dark red circles with whitish centers. Frozen and permanent sections were reported as showing neuroblastoma, metastatic to liver. Postoperative roentgen therapy was then given, and 16 treatments were delivered in 20 days, from November 23, 1938 to December 12, 1938. The technical factors employed were: 160 kv. peak, 6 ma., 0.5 mm. Cu and I mm. Al (added filter); 50 cm. target skin distance (half value layer unknown but estimated to be 0.7 mm. Cu). The free air dose rate at 50 cm. was 8 r/minute. The daily air dose was 100 r, except for the first day when 75 r was given. Four entry portals, ranging in size from 14×9 cm. to 16×10 cm., were employed. The data are insufficient to establish with certainty which structures were included in the beam, but when applied to another infant of identical weight with the same lesion, these fields extended from the level of the mid-dorsal spine to the true pelvis. The total air dose was as follows: 375 r to an anterior field and 400 r each to posterior,

This investigation was supported in part by grants from the Medical Foundation, Inc., Boston, Massachusetts, and the National Cancer Institute, NIH, USPHS #CY-3335, and C-6516.

<sup>\*</sup> From the Department of Radiology, the Department of Pathology, and the Children's Cancer Research Foundation, the Children's Hospital Medical Center, and the Departments of Radiology and Pathology, Harvard Medical School, Boston, Massachusetts. Presented at the Forty-fourth Annual Meeting of the American Radium Society, New York City, April 2-4, 1962.

right lateral, and left lateral ports. Isodose curves plotted for the technique employed demonstrated that the right kidney received a maximum dose of 1,400 r and a minimum dose of 1,345 r, while the values for the left kidney were 1,450 r and 1,400 r, respectively. In similar fashion, the dose to the vertebral bodies and the skin was calculated to be 1,400 r. Using an appropriate conversion factor, 15 the estimated bone dose in rads was 2,660. In the above calculations, no correction was made for the lack of homogeneity of the irradiated tissues.

The patient improved steadily while undergoing radiation therapy, and the liver returned to normal size. During the ensuing 20 years, she had no further difficulty with the neuroblastoma nor with development, although at first she seemed retarded in speech and walking. Her stature was consistently described as being small for her age. She was hospitalized when 6 years old for an oblique fracture of the left femur. A system review at that time showed no abnormalities other than the laparotomy scar. Urinalysis, however, revealed a slight trace of albumin, I to 3 red blood cells, a few epithelial cells, and rare granular casts. Normal secondary sexual characteristics and menarche appeared by the time she was 12 years of age. She was again hospitalized at the age of 16 for the removal of a mass, 2 cm. in diameter, from the right breast. This proved to be a fibroadenoma. A physical examination at this time was otherwise unremarkable; the blood pressure was recorded as 108/76 mm. Hg.

In 1955 and 1956, skin lesions were excised. The first of these, originating on the right chest wall, was a trichoepithelioma. The second, a 7 mm, scaly area involving the skin over the twelfth dorsal spine, was a basal cell carcinoma. She was hospitalized at the age of 20 on July 27, 1958, when her mother reported gradual weight loss, anorexia, frequent bowel movements and cough associated, on occasion, with bloody sputum. On entry, the patient was pale, thin, and dyspneic. She was acutely distressed and had a dry hacking cough. Her weight was 100 pounds; height, 5 feet, 5 inches; pulse, 156; blood pressure 190/140 mm. Hg; temperature, 101°F. Moist rales were audible at both lung bases. A lobular mass was felt per rectum in the cul de sac, apparently separated from the uterine fundus. The patient became extremely ill shortly after admission and died suddenly, before laboratory or roentgen studies could be obtained. The clinical diagnoses were recurrent neuroblastoma involving the liver, with possible adrenal involvement, and renal decompensation with hypertensive failure.

An autopsy was performed. Bilateral pleural effusions, consisting of 500 cc. of thin vellowish fluid on either side, were found in association with extensive, bilateral, acute bronchopneumonia. The heart weighed 300 gm., compared to a predicted normal value of 180 gm.<sup>22</sup> The peritoneal cavity contained 600 cc. of thin yellowish fluid, and fibrous adhesions were present between the anterior surface of the liver and the anterior abdominal wall. Gross examination of the liver, which weighed 1,300 gm., revealed multiple, nodular, soft, grayish-yellow areas ranging from 1 to 4 cm. in diameter, with a homogeneous appearance on cut surface. The left kidney weighed 170 gm. and the right, 100 gm. The renal capsules were both stripped with considerable difficulty. The right adrenal gland was normal, but the left was markedly enlarged, measuring 8×7×6 cm., with a firm, nodular texture and a fleshy, whitish-gray cut surface. The left ovary, which weighed 80 gm., was firm and nodular and measured 7×8×9 cm. The cut surface was firm and contained many specks of calcification.

Histologic examination of the lungs showed edema and uremic changes together with an acute bronchopneumonia. The perirenal areolar tissue was fibrotic and adherent to the renal cortex and was infiltrated by giant cells. Increased cellularity and ischemia of glomeruli, irregular, hyperchromatic tubular epithelium, and a fibrous endarteritis of small vessels were seen in the renal parenchyma. A diffuse and chronic interstitial inflammatory process was superimposed on this picture. These changes are consistent with radiation nephritis (Fig. 1, A, B and C)). The hepatic sections showed fibrotic and regenerative changes (Fig. 2). The left adrenal tumor proved to be a well-differentiated ganglioneuroma.

#### DISCUSSION

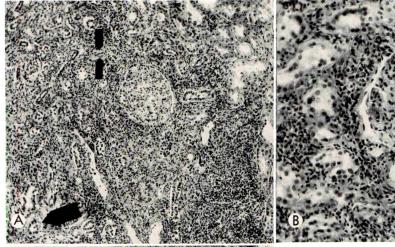
Luxton<sup>11,12</sup> has proposed the following classification of radiation nephritis, based on extensive experience and study of the clinical and anatomic features of this condition.

1. Acute radiation nephritis which ensues after an asymptomatic latent period of 6 to

12 months dated from initiation of treatment. There then develop, over a short period, the signs and symptoms of cardiac and renal failure. The urinary changes are characterized by albuminuria, low specific gravity, granular casts and microscopic hematuria. Severe normochromic, normocytic anemia and cardiomegaly are early and constant features.

2. Chronic radiation nephritis which may develop insidiously over a long period or be the residual of the acute form. The usual clinical and biochemical features of chronic glomerulonephritis are seen: e.g., hypertension; anemia; albuminuria, low specific gravity; granular, hyaline, or epithelial casts; and moderate elevation of the blood urea values.

- 3. Benign hypertension which resembles benign essential hypertension. Abnormal blood pressure readings are first noted only after a long latent period measured in years.
- 4. Malignant hypertension which evolves precipitously after a symptom-free interval of 18 to 24 months. A rapid, irreversible downhill course then follows and is characterized by hypertension, anemia, and renal failure in their most severe forms. Death invariably ensues within weeks. Kunkler et al., 9 in their study of renal tolerance to roentgen rays, concluded that a dose of 2,300 r in 5 weeks to two-thirds or more of the total renal volume is required to produce radiation nephritis. In addition to the cases reported by these authors, 13 other patients in whom sufficient data for





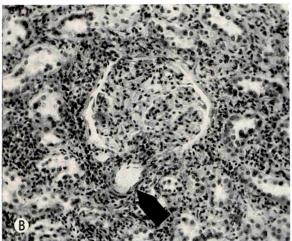


Fig. 1. Kidney. (A) The renal tubules are lined by irregular, hyperchromatic cells with high nuclear-cytoplasmic ratios. There are arteriosclerotic changes (arrows) and a superimposed round cell infiltration between the tubules. (Hematoxylin and eosin stain. Medium power.) (B) The glomerular capsular membrane is thickened. There is endothelial swelling and proliferation within the anemic glomerular capillaries. Telangiectasia of a glomerular arteriole is apparent (arrow). (Hematoxylin and eosin stain. High power.) (C) Branch of renal artery near hilus. There is a thick fibrous subintimal plaque which narrows the arterial lumen. Chronic inflammatory changes are present in the surrounding adventitial tissues. (Hematoxylin and eosin stain. Medium power.)

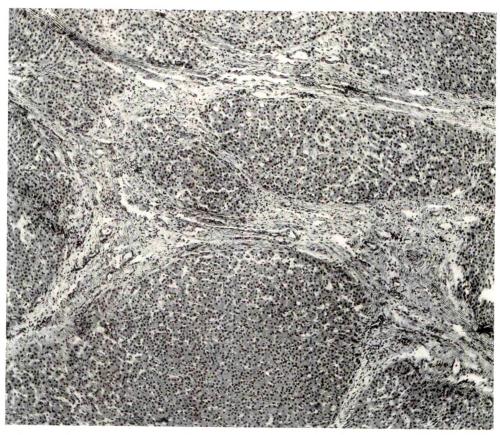


Fig. 2. Liver. The normal architecture is distorted. Fibrous bands separate lobules of varying size and there are small foci of inflammatory cells in the portal areas. Minimal vascular thickening is present. (Hematoxylin and eosin stain. Medium power.)

dose estimation was provided have been described. Seven of these were adults who received doses ranging from 1,750 to 4,600 r, over periods ranging from 25 to 60 days. 1,4,8,10,26 The 6 children heretofore reported received doses estimated to be in excess of 2,000 r over a 2 to 5 month interval, some of them in repeated courses. 1,6,19,28 After short latent periods, all developed acute radiation nephritis and died, except for the patient described by Cogan and Ritter. This child had only the left kidney treated, and a left nephrectomy resulted in prompt and complete recovery.

The patient herein reported best approximates the primary chronic radiation nephritis type of Luxton. Her course also was characterized by a protracted symptom-free interval, despite the presence of a chronic renal lesion as suggested by the

findings on urinalysis at the age of 6 and the histologic features at autopsy. That the hypertension noted shortly before death had been present for some time is indicated by the finding of cardiomegaly at autopsy. The exceptionally long silent period of 20 years before the terminal phase is of special interest, as is the small dose of irradiation received by the kidneys. This amounted to a maximum of 1,450 r in 20 days, the smallest dose recorded up to now known to have caused death. However, the treatment period was shorter than those described in the literature, making direct comparison of dosages difficult.

Zuelzer et al.<sup>28</sup> have suggested that in young children in the active phase of growth the kidneys may be more sensitive to the effects of radiation than those of adults. The patient reported, who was ir-

radiated when but 3 months old, may be an example of such a hypersensitivity related to age. However, there appears to be considerable variation among adults in their response to irradiation. Such an idiosyncrasy has been postulated by Luxton and is perhaps exemplified by the cases reported by Cogan and Ritter. Two of their patients received only modest doses over a prolonged treatment period yet developed frank renal lesions.

The occurrence of a basal cell carcinoma in this patient within the field of radiation therapy 18 years after treatment is of interest from several points of view. The patient's youth, the location, and the history of prior irradiation are noteworthy. 14,20,21 Studies of large groups of patients with basal cell carcinomas show

that, at most, I per cent of the total are under 20 years of age. 7,17,23 Three such cases among those recorded in the literature had a history of prior irradiation, but the doses employed are not given. 14,18,23 The 5 year old boy described by Scharnagel and Pack<sup>18</sup> is of particular interest since multiple basal cell carcinomas developed within a treatment field employed for thymic irradiation shortly after birth. The illustrations accompanying their report show a heavily pigmented area, suggesting a high skin dose. Patient A. B., who received a maximum skin dose of 1,400 r, had definite microscopic changes indicative of irradiation effect in the area where the basal cell carcinoma became evident 18 years after the time of treatment (Fig. 3); however, as in the case of Scharnagel and Pack, she also

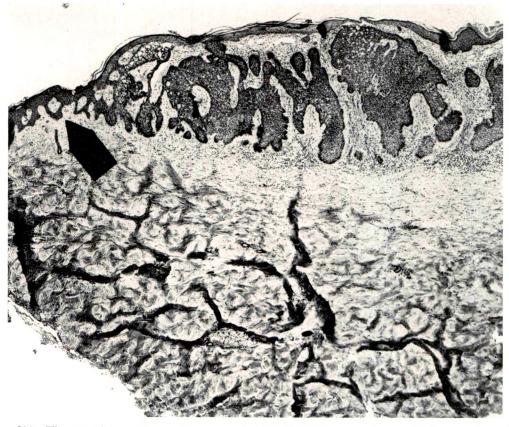


Fig. 3. Skin. There are late radiation changes consisting of hyperpigmentation, multiplication, irregularity of rete pegs (arrow), and a thickened layer of heavy hyaline bundles of dermal collagen. In the center of the figure is a basal cell carcinoma with multicentric proliferation of masses of basal cells beneath an apparently intact surface. Hyperkeratosis also is present. (Hematoxylin and eosin stain. Low power.)



Fig. 4. Anteroposterior view of the lower dorsal spine of A.B. at the age of 17. The vertebral bodies are small in all diameters with slight irregularity of contour at the interspaces which are narrowed. The heads and necks of the ribs are misshapen and reduced in size. The neural arches of the ninth, tenth, and eleventh dorsal vertebrae are abnormal. These latter represent developmental variations since changes were evident on pretreatment roent-genograms.

developed a skin neoplasm in the area presumably outside the direct beam. A trichoepithelioma was removed from her axilla at the age of 17. Possibly the thymic treatment included the area in question. It is conceivable that a propensity was present toward the development of basal cell lesions, which was heightened by the irradiation given. It is more probable when the unusual location of the epithelioma and her age are considered that roentgen irradiation, although in modest dosage, was instrumental in its appearance, notwithstanding the fact that roentgen irradiation is more likely to induce squamous, rather than basal cell carcinomas.<sup>24</sup>

The changes following irradiation of the vertebral spine have been well described by Neuhauser *et al.*<sup>16</sup> Our patient exhibited, at a later stage, the basic features outlined by them, consisting of reduction in size and irregularity of contour and changes in the posterior ribs as well (Fig. 4).

Regeneration of liver lobules and extensive fibrosis were found at postmortem examination. The consensus of the pathologists reviewing the slides was that these changes were the result of postnecrotic scarring. The literature contains little data on the very delayed effects of small doses of irradiation on the liver, particularly in the case of an organ so heavily permeated with tumor as this. In our case it is not possible to state how much is to be ascribed to late radiation injury and how much to healing of the hepatic lesions after treatment. She also developed ovarian and breast tumors which proved to be benign. What part, if any, radiation therapy played in their origin is a matter for conjecture. The finding of a benign ganglioneuroma in the left adrenal gland on postmortem examination is of interest. The possibility that a malignant neuroblastoma matures to a benign ganglioneuroma was emphasized by Cushing and Wolbach.3 It may be postulated that in our patient a primary neuroblastoma had been present in the left adrenal and underwent such a change.

#### COMMENT

Radiation therapy is often employed, together with surgery and chemotherapy, in the management of children with cancer, and cure of the disease is obtained not infrequently. Careful continuing scrutiny of the patient must, nonetheless, not be relaxed as the period free of disease lengthens because the likelihood of certain late radiation effects becomes greater with time. Eighteen years elapsed before the reported patient developed a skin cancer, and 20 years were required before the smoldering renal lesion erupted to terminate fatally.

The insidious onset and the long latent period associated with radiation injury make vigilant surveillance of the patient mandatory for life. The lethal potential of these lesions must be kept in mind; benign processes, both functional and neoplastic, may be the precursors of their more malignant counterparts. Prompt attention to the earliest manifestations of radiation injury and their correction when possible may avoid such a malignant eventuality.<sup>5,13</sup>

Undue fear of possible late deleterious effects, on the other hand, should not deter the radiotherapist. The relative risks should be weighed with care. When a decision to treat is made, maximum ingenuity and meticulous technique should be exercised to exclude from the beam all normal structures not essential to the treatment program.<sup>25</sup> Fields should be shaped to conform exactly to the tumor-bearing area, introducing blocks wherever necessary. Generous use of portal roentgenograms is advisable to localize, accurately, the treatment ports. It is particularly true in children that the smallest dose known to be effective, delivered to the smallest requisite volume, is the therapeutic ideal.

#### SUMMARY

Late complications associated with roentgen therapy of children are discussed and an illustrative case is reported. The patient was irradiated as an infant and developed, over a period of 20 years, lesions exemplifying three of the major categories of late radiation effects. Growth disturbance was sustained by the vertebral spine, functional impairment by the kidneys, and tumor induction by the skin.

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# ANESTHESIOLOGIC PROBLEMS IN PEDIATRIC RADIOLOGY\*

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THE increasing demand for special roentgenologic investigations in infants and children presents certain recurrent anesthesiologic problems, which we have attempted to solve along the following principal lines.

Every diagnostic procedure must involve the least possible risk to the patient; the procedure must be tolerable, if not pleasant, to the patient; and its technical difficulties must be minimized so that the investigation can be accomplished smoothly and as swiftly as possible.

Most roentgenologic investigations in children requiring anesthesiologic assistance will be found in one of the following 4 groups: (1) cardiac catheterization and angiocardiography; (2) neuroradiologic examinations; (3) laminagraphy; and (4) bronchography.

Although each group poses its own anesthesiologic problems, their handling has one factor in common—immobilization is mandatory. This can be obtained either by profound sedation or general anesthesia. For sedation we have found a combination of pethidine (meperidine), promethazine (phenergan) and chlorpromazine (largactil) very useful. These drugs in combination produce an ataractic state characterized by a predisposition to fall asleep and an indifference to disturbing stimuli, as long as they are not painful. This combination was originally advocated by Laborit and Huguenard<sup>10</sup> in 1952, as an adjunct to induced hypothermia, and they named it a "lytic cocktail." It has been used for preanesthetic medication.

In 1958 Smith *et al.*<sup>12</sup> reported favorably on the sedative effect of the lytic cocktail in children who underwent cardiac catheterization. We have arrived at similar re-

sults.<sup>5</sup> The mixture employed by us contains in 1 ml. 28 mg. of pethidine, 7 mg. of promethazine and 7 mg. of chlorpromazine. The standard dose for preanesthetic medication is 0.05 ml. per kg. body weight. When more powerful sedation is desired, as for cardiac catheterization, the dose is doubled to 0.1 ml. per kg. body weight. A total dose of 2.5 ml. should not be exceeded.

The doses are reduced by 25 per cent if the general condition of the child is poor. For nervous children, on the other hand, and for children with pathologically increased muscle tone, as in spastic paralysis, somewhat larger doses can be useful. The injection is given intramuscularly to avoid local irritation.

In 5 to 15 minutes after the injection, the medication takes effect and the child becomes sleepy, but cooperative. It will dose off when left alone but awakens and responds adequately when addressed. Maximal effect is obtained after 20 to 30 minutes, and the sedation will last for 2 to 3 hours.

It should be mentioned, however, that while the great majority of routine roentgen examinations can be performed without sedation provided that the children are normal and time is taken to ease their apprehensions, difficulties will arise if the patient is unduly nervous or has a disordered or inferior mental state. Much agony can be spared and less time wasted if these children are given either 0.05 or 0.1 ml. per kg. body weight of the lytic cocktail before they go to the Department of Radiology.

In order to assess more clearly the duration of the sedative effect of the lytic cocktail, 0.1 ml. per kg. was given to 12 children, aged from 1 month to 10 years, who were not subjected to any procedure. They

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all became sleepy after 5 to 15 minutes, fell asleep after 20 minutes, could take liquids after  $\frac{3}{4}$  hour and were completely unaffected after 5 hours.

# CARDIAC CATHETERIZATION AND ANGIOCARDIOGRAPHY

Although cardiac catheterization is a relatively common diagnostic procedure, the current literature bears evidence that opinions vary considerably as to the preferable anesthesiologic approach to this procedure, in which steady circulatory conditions are a prerequisite. The commonly advocated techniques include inhalational anesthesia with and without endotracheal intubation; inhalational anesthesia in combination with muscle relaxants; in intermittent intravenous or intramuscular injection of thiopentone; and rectal administration of either thiopentone or tribromethenol (avertin).

The anesthesiologic procedure which we recommend is as follows: the child is seen on the day before investigation for the usual check-up, and if he is old enough to comprehend, the next day's procedure is explained to him. No preanesthetic medication is ordered on this visit, but instructions are given that the child should be in a fasting state for the procedure since general anesthesia would be required if angiography is necessary.

The next day the child upon arrival at the cardiopulmonary laboratory receives an intramuscular injection of 0.1 ml. per kg. body weight of the lytic cocktail and after 15 minutes is ready for catheterization. Since the threshold for pain does not seem to be altered to a great extent by the lytic cocktail, a local analgesic is injected at the selected cutdown site. Rarely has it been necessary to increase the dosage of the lytic cocktail, but when the sedation is judged insufficient an additional dose, not exceeding 50 per cent of the first, is given 15 minutes after the initial dose. No contraindications to this method of sedation have been encountered; even children with severe cardiac decompensation have not been adversely affected.

When angiocardiography is to follow the catheterization, no further medication is given prior to the induction of general anesthesia. The anesthetic agents which are used are  $N_2O$  for infants and intravenous thiopentone and  $N_2O$  for older children. Orotracheal intubation is facilitated and immobilization during the procedure is ensured with succinylcholine—a short acting muscle relaxant—and the child is in apnea while serial roentgenograms are made, after having been hyperventilated with pure  $O_2$  or a 50 per cent mixture of  $N_2O$  in  $O_2$ .

Since the upper airways are outside the examination field, any anesthetic equipment suited for pediatric anesthesia can be used. The anesthetic method secures a free airway, adequate oxygenation and an immobile, unconscious patient. Furthermore, it enables the anesthetist to be protected behind a shield during the brief period of roentgenography. The child awakens shortly after the anesthesia is administered.

Thoracic aortography presents identical anesthesiologic problems. For abdominal aortography general anesthesia is not necessary.

#### NEURORADIOLOGIC EXAMINATIONS

General anesthesia is used for carotid and vertebral arteriography since immobilization of the patient prevents unnecessary trauma to the vessel wall, quite apart from the fact that movements will distort the roentgenographic picture. The anesthetic equipment is outside the field of investigation and does not interfere with this.

Premedication is 0.05 ml. per kg. body weight of the lytic cocktail given intramuscularly  $1\frac{1}{2}$  hours before the performance of arteriography. The anesthetic agents are either halothane, delivered from a Fluotec Mark II vaporizer, or thiopentone— $N_2O$ —muscle relaxants. Orotracheal ntubation is routinely performed, and ventilation is maintained by intermittent manual positive pressure breathing (controlled respiration).

Air encephalography presents special problems; while in the anesthetized state, which always interferes with vasomotor control, the patient must change position drastically several times, and some part of the anesthetic equipment is perforce inside the field of the roentgenologic investigation at all times.

Premedication is 0.05 ml. per kg. body weight of the lytic cocktail intramuscularly. With the child in the supine position, anesthesia is induced with N<sub>2</sub>O or with thiopentone, and orotracheal intubation is performed under succinylcholin-induced muscle paralysis. The wall of the endotracheal tube is reinforced by a coiled wire, which prevents kinking of the tube when the head is moved, and a free airway is thus maintained. Anesthesia is continued with halothane—0.5 per cent usually suffices—in a N<sub>2</sub>O-O<sub>2</sub> mixture, which never contains less than 30 per cent oxygen. Controlled respiration is employed.

After intubation the child is put in the sitting position, his head is suspended in a Glisson's loop (Fig. 1), and the axillae, buttocks and feet are additionally supported, whereafter the subarachnoid insufflation can take place.



Fig. 1. Position of patient for lumbar insufflation.



Fig. 2. Anesthetic equipment consists of a breathing bag with two openings, an Ayres T-piece and a flexible endotracheal catheter.

The equipment connecting the endotracheal tube with the anesthetic machine should be light and take up little room so that, irrespective of the body position, the head of the child can come into close contact with the roentgen cassette. Furthermore, the fixation of the equipment should be such that the anesthetist can leave the child during the numerous, but brief, periods of roentgenography. The equipment we have found useful in these cases consists of a breathing bag with two openings, an Ayres T-piece, and a flexible endotracheal catheter (Fig. 2).

Moderately heavy premedication in combination with small quantities of general anesthetics, in our minds, makes it easy to vary quickly the level of anesthesia according to the needs of the procedure. In this way the main part of the investigation can be accomplished with light anesthesia, only to be deepened at certain points, as for instance, to curb the reflexes that may arise when air enters the lateral ventricles.

We have deliberately avoided the prolonged use of muscle relaxants, since the diagnosis of apnea of cerebral origin would be less readily made if the possibility of prolonged curarization had to be taken into account. Furthermore, we feel that overstretching of ligaments and nerves is more likely to occur with curarization during a

procedure which requires frequent changes in position.

#### LAMINAGRAPHY

Laminagraphy in children is commonly employed for thoracic conditions and does not generally call for sedation or anesthesia. Of special interest to us, however, has been laminagraphy of the temporal bones.<sup>4,5</sup> The patient must be kept from moving during the actual laminagraphy, since the visualization of finer details, for instance in the tympanic cavity, is achieved with cuts of not more than 1 mm.

Laminagraphy is performed with frontal as well as lateral sections.

Children up to 10 months of age usually sleep soundly throughout the procedure after o.1 ml. per kg. body weight of the lytic cocktail is given intramuscularly 1/2-1 hour in advance. In older children this does not hold true, since they are frightened by the movement and noise of the rotating polytome. In order to avoid the presence of anesthetic equipment at the head, thiopentone is given rectally in a dose of 20 mg. per kg. body weight for the age group below 4 years and 30 mg. per kg. for those from 4 to 10 years. Children above the age of 10 years need no medication. The thiopentone in an oil suspension (pentothal rectal suspension, Abbott), is delivered ready for use in a disposable plastic syringe, and its administration is easy. No measures need to be taken to empty the bowel before the application. The children must be in a fasting state because regurgitation of stomach contents is a hazard, and equipment for tracheal intubation and oxygen administration must be at hand. The children should not be premedicated; narcotics should especially be avoided since these in combination with the thiopentone may cause undesired respiratory depression. The children should be under constant supervision from the time of administration of the anesthesia until they awaken. When asleep, the children should be placed on their side to minimize soft tissue obstruction of the upper airways.



Fig. 3. T-shaped connector used for bronchography.

#### BRONCHOGRAPHY

In children this procedure requires general anesthesia. Premedication is 0.05 ml. per kg. body weight of the lytic cocktail and anesthesia is N2O—halothane,—after induction with thiopentone if needle injection is possible,—and orotracheal intubation after succinylcholine. The endotracheal catheter is mounted before intubation on one of the three openings of a Tshaped connector (Fig. 3). Through the second opening ventilation and anesthesia are maintained, and through the third contrast medium is introduced through a polyethylene catheter. This opening is kept occluded with a finger. After the bronchograms are made, as much of the residual contrast medium as possible is aspirated.

#### CONCLUSION

The technical advances of recent years have reduced the time of exposure in roentgenologic studies, but even so, it is difficult to obtain immobilization of a child in a suitable position and for the necessary period of time in procedures of longer duration. This requires the constant presence of one assistant who must stay with the child even during roentgenography and is thus subjected to a considerable dose of radiation.

These problems can be alleviated in the procedures which are not painful or otherwise disturbing to the child by sedation with a combination of promethazine, chlor-

promazine, and pethidine, the "lytic cocktail," given intramuscularly. Thereby adequate sedation is produced for 1 to 3 hours. The hazards of a general anesthesia are avoided, and as no anesthetic armamentarium is needed, good working conditions are provided for the radiologist.

For procedures painful or frightening to children, general anesthesia is required. With the "lytic cocktail" used as premedication, the administration of the anesthesia is easily performed and undesired interference with vital functions seems small.

In children who are uncooperative, be it secondary to nervousness or mental retardation, a quiescent state can likewise be induced with the "lytic cocktail," in preparation for the more simple investigations.

#### SUMMARY

Attention is drawn to the usefulness of the conbination of promethazine, chlorpromazine and pethidine as a sole sedative or a premedicant in children who are to undergo roentgenologic procedures which are so prolonged, painful or frightening that immobilization cannot be obtained without medication. Various technical problems involved in pediatric anesthesia for roentgenology are described, and the need for special anesthetic equipment is stressed.

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## GAS IN THE FETAL SKULL\*

#### A NEW SIGN OF INTRAUTERINE FETAL DEATH

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**)**F ALL the roentgenologic criteria of intrauterine fetal death, the only one that is pathognomonic is the demonstration of gas within the fetus.3 Intrafetal gas is a frequent sign of intrauterine fetal death since it is present in nearly 50 per cent of all cases of intrauterine fetal death.2,4 Roberts,6 in 1944, first described gas in the fetal circulation as a new sign of intrauterine fetal death. Since that time, numerous cases of intrafetal gas, both intravascular and extravascular, have been reported. Gas outside the vascular system has been reported in the retroperitoneal tissues, the thoracic wall, the scalp, and the peritoneal and pleural cavities. 2,4,5,6,10 In most instances, the presence of extravascular gas is accompanied by gas within the circulatory system.3 In only one case, that reported by Friedman and Meyer,3 was extravascular (intraperitoneal) gas demonstrated, with no evidence of intravascular gas. The case to be reported here is the first in which gas was visualized within the fetal skull. With the present case report, the total number of recorded cases of intrafetal gas is 98.

#### REPORT OF A CASE

R.G., a 25 year old white woman, Gravida II, Para I, was referred to the Radiology Department, USAF Hospital Keesler, for roentgenographic abdominal study on May 2, 1962. A previous pregnancy had been uncomplicated. The present pregnancy had been uneventful until 6 days prior to this study, when fetal movements apparently ceased. However, on the day of the visit to the clinic, fetal heart tones were heard. The day of the examination the patient experienced a bloody vaginal discharge and hypotension with a blood pressure of 84/30. Previous blood pressure measurements were in the range of 129/74. The fundal height was 22 cm.

and the expected day of delivery was August 1, 1962.

Roentgenograms (Fig. 1 and 2) revealed a fetus of approximately 7 months' gestation in a breech presentation with collapse and angulation of the fetal spine in erect views, probable overlapping of the fetal cranial bones, and a gas-fluid level within the fetal calvarium. No other fetal gas was identified.

The patient was admitted to the hospital on the day of the examination and went into spontaneous labor that evening, delivering a stillborn, macerated fetus the following day. The mother's postpartum course was uneventful.



Fig. 1. Erect anteroposterior roentgenogram of maternal abdomen demonstrating gas-fluid level within the fetal skull and hyperflexion of the fetal spine.

<sup>\*</sup> The contents reflect the personal views of the authors and are not to be construed as a statement of official Air Force policy.

<sup>†</sup> Department of Radiology.

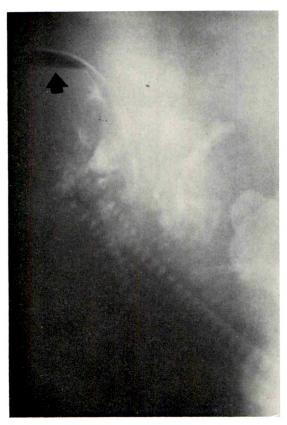


Fig. 2. Erect oblique roentgenogram of maternal abdomen. Note gas within the fetal cranium.

A roentgenogram (Fig. 3) of the stillborn fetus confirmed the presence of intracranial gas and again no other intrafetal gas was demonstrated.

Postmortem Examination.\* The body was that of a normally developed (for age), extremely macerated female fetus, weighing 1,770 gm. and measuring 41.5 cm. in crown-to-heel length. The facies was grotesque, due to overlapping of the cranial bones and subcutaneous edema.

The body was opened using the usual Y-shaped incision. An attempt was made to aspirate the gas from the cranial vault but without success. Cultures taken from the cranial vault showed no growth. The brain substance appeared to have been normally developed and the ventricles of the brain were not enlarged. The lungs were compressed against the mediastinum and the pleural cavities were filled with serosanguineous fluid. The heart and great vessels

were normally arranged. Exploration of the abdomen disclosed autolysis of all the abdominal viscera which were normally placed. The placenta was enlarged and edematous, weighing 695 gm. and measuring 18×17×3 cm., but no infarcts were noted.

The final pathologic diagnoses were: (1) macerated still-born female fetus, consistent with 7 plus months of gestation; and (2) intrauterine fetal death, cause undetermined.



Fig. 3. Erect anteroposterior roentgenogram of stillborn fetus demonstrating gas-fluid level within the fetal skull.

<sup>\*</sup> Postmortem examination was performed by Doctor Richard Neale.

#### DISCUSSION

Intrafetal gas is generally small in amount and is almost always confined to the fetal vascular system.<sup>10</sup> Of the 98 reported cases, only 10 demonstrated gas in sites outside the vascular system.<sup>2,4,5,6,10</sup> Other than the present case, the case reported by Friedman and Meyer<sup>3</sup> is the only one in which extravascular gas alone was demonstrated.

Gas within the fetus appears much earlier than any other roentgenographic sign of fetal death. In Stewart's series of 31 cases, the shortest interval following cessation of the fetal heart tones, where gas was demonstrated *in utero*, was 12 hours, and in 6 instances it was observed in 24 hours. In 84 per cent of his series, gas was present within 10 days. Intravascular gas is most frequently observed in the heart and portal veins. <sup>10</sup> In vertex presentations, it is found most frequently and in greatest volume in the heart, portal veins, distal ascending aorta and iliac vessels.

In all of the cases reported, maceration of the fetus was described. The quantity of gas present did not bear a constant relationship to the degree of maceration. The connection between the process of maceration and the formation of gas in the fetus is somewhat obscure. No definite maternal factor has been found to be associated with fetal gas formation.

Some disagreement exists as to the composition of the gas and to the method of its formation. Stewart<sup>8</sup> and Stewart and Hytten<sup>9</sup> aspirated the gas from 7 dead infants immediately following delivery. An analysis of the gas revealed a remarkably constant percentage of carbon dioxide, 65 to 80 per cent, with an average of 70 per cent. The remaining percentage in each case was almost entirely oxygen. This analysis differs with the findings of Crick and Sims,2 which indicated that the gas is composed almost entirely of nitrogen with a small quantity of carbon dioxide and oxygen. Most investigators, however, are in agreement with Stewart.

Stewart's<sup>10</sup> explanation for the production of the gas is that fetal blood contains a high proportion of reticulocytes and that they continue to metabolize for some time after death. (Reticulocytes have the ability to do this anaerobically.) Glucose is metabolized to a lactate, glycerophosphate and pyruvate. As a result, the pH of the blood is lowered and carbon dioxide is evolved from the bicarbonate. The liberation of oxygen is due to its relaease from oxyhemoglobin when hemoglobin breaks down after death. This theory does not explain the findings of Crick and Sims, and as Stewart points out, although nitrogen can evolve from the blood, it can do so only under considerably reduced pressure. Such pressures do not occur in utero.

The presence of gas in extravascular locations is not as easily explained. Two possible sources (excluding anaerobic infection) are postulated: (1) the gas may arise from breakdown of tissues, similar to that believed to occur in the blood; or (2) the gas may form in the blood and subsequently diffuse into the surrounding tissues. The fact that the gas was confined to the vascular tree in 86 of the 98 reported cases suggests that the latter explanation is correct. The well known ready diffusibility of carbon dioxide and oxygen in body tissues supports this. This ease of diffusion may also account for the cases reported in the literature in which gas was noted on one set of the prenatal roentgenograms, but disappeared on subsequent studies prior to delivery.

#### DIFFERENTIAL DIAGNOSIS

Intrafetal gas shadows must be differentiated from: (1) maternal gas shadows; (2) fetal subepidermal fat deposits and rarely (3) gas in the amnionic cavity.<sup>3,7</sup>

In most instances, with roentgenograms of high quality and free of fetal movement, intrafetal gas can be differentiated from maternal gas and the fetal fat outline without difficulty. Intrauterine gas is rare and is almost always seen following rupture of the membranes (either spontaneous or

artificial) or in association with amnionitis. In the latter the clinical features of maternal toxicity aid in the differentiation. If fetal death is suspected, an erect anteroposterior roentgenogram of the abdomen should suffice for the initial survey. If this does not provide any evidence of fetal death, an erect lateral roentgenogram should be taken. It may be desirable to replace the lateral view with an oblique view calculated to show the important areas of the fetus to best advantage. The erect position is stressed because it will demonstrate an air-fluid level if one is present.

#### SUMMARY

A case is presented of intrauterine fetal death diagnosed by the presence of gas in the fetal skull. This is believed to be the first such case reported in the literature.

Intrauterine fetal gas, whether intravascular or extravascular, remains the one pathognomonic sign of intrauterine fetal death.

Intrafetal gas is a frequent sign of intrauterine fetal death since it is present in nearly 50 per cent of all cases of intrauterine fetal death.

Since gas in the fetus occurs earlier than any of the other roentgenographic signs of fetal death, early roentgen examination is indicated in all cases of clinically suspected fetal death.

The composition of intrafetal gas and a probable method of gas formation are discussed.

William H. Northway, Captain, USAF, MC Department of Radiology USAF Hospital Keesler Keesler Air Force Base, Mississippi The authors are indebted to Dr. Donald L. Block and the Department of Obstetrics and Gynecology of the USAF Hospital Keesler for permission to publish the details of the case under their care. The authors are also indebted to A1C Joseph Jenkins, who made the reproductions and to Miss Mary Hord who typed the manuscript.

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## AMNIOTIC PULMONARY EMBOLISM\*

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AMNIOTIC pulmonary embolism is a rare intrapartum or early postpartum complication. Because the condition is often rapidly fatal, roentgenograms are usually not obtained, and search of the radiologic literature has revealed only one such previous report. Nonfatal cases have probably occurred more frequently than the literature would indicate, being diagnosed as pulmonary edema of undetermined etiology or idiopathic heart failure. It is therefore felt worthwhile to report a case of this condition recently observed at this hospital.

Although amniotic pulmonary embolism can be diagnosed with absolute certainty only by microscopic examination of the lungs, the clinical course presented by the patient to be discussed was sufficiently characteristic for this diagnosis to be made. An increased awareness of this condition on the part of radiologists should lead to more frequent recognition of nonfatal cases.

#### REPORT OF A CASE

A 30 year old woman was admitted to the hospital in labor following an uneventful pregnancy. She had had two previous normal pregnancies and deliveries and one spontaneous abortion. There was no history of cardiovascular, pulmonary, or renal disease. The uterus was abnormally large. Bloody show had taken place when labor began. The membranes were ruptured and labor progressed in a normal manner. Identical twins were delivered without difficulty. Inhalation anesthesia was used for a total of 40 minutes during delivery and repair of an episiotomy. Total time of labor was I hour, 36 minutes. The placenta was expelled spontaneously and no excessive blood loss took place. The patient was sent to her room in good condition. One thousand cubic centimeters of 5 per cent dextrose in water containing I cc. of pitocin was given intravenously over a 2 hour period.

Approximately 2 hours after delivery, the patient became nauseated and vomited. Shortly thereafter, she started to cough, became dyspneic and apprehensive. Examination revealed cyanosis, rapid pulse, and coarse rales in both lungs. An electrocardiogram showed sinus tachycardia with a rate of 150 and myocardial ischemia. The blood pressure dropped slightly. Tracheal aspiration yielded considerable frothy, bloody mucus.

Treatment consisted of oxygen, digitalization, atropine, and antibiotic coverage. Gradual improvement occurred, with the electrocardiogram returning to normal the next day. The first chest roentgenogram (Fig. 1) was made 30 hours after onset of the acute symptoms. At that time the patient was still somewhat cyanotic, though no longer dyspneic, and oxygen was discontinued just before she was brought to the radiology department.

The cyanosis as well as the rales in the lungs cleared gradually. A roentgenogram taken 2 days after the first one showed considerable clearing (Fig. 2). Laboratory studies including routine urine and blood studies as well as a transaminase test were normal. The patient was

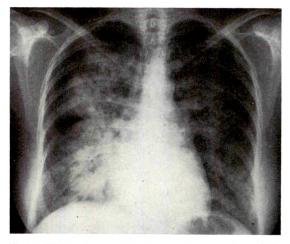


Fig. 1. Thirty hours after onset of acute episode. Bilateral perihilar infiltration, more extensive on the right, and slight cardiomegaly consistent with physiologic enlargment in pregnancy are seen.

<sup>\*</sup> From the Department of Radiology, St. Francis Memorial Hospital, San Francisco, California.

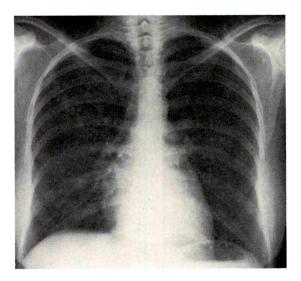


Fig. 2. Forty-eight hours after first chest roentgenogram. Nearly complete clearing in seen.

discharged from the hospital in good condition on the seventh postpartum day. A follow-up roentgenogram of her chest taken 5 months after discharge (Fig. 3) showed normal appearance.

#### DISCUSSION

Amniotic pulmonary embolism is a rare cause of obstetrical death. The incidence has been estimated as I in 8,000 deliveries;6 however, at one institution, 40,000 deliveries were performed with only I case being discovered.2 It is probable that many nonfatal cases have not been diagnosed or reported. The condition was first described in detail by Steiner and Lushbaugh6 in 1941. They described the postpartum findings in 8 cases of unexpected obstetrical death and found edema and alveolar hemorrhage in the lungs. The small pulmonary arteries were plugged by emboli composed of epithelial cells, amorphous debris, and meconium. These investigators also injected human amniotic fluid into the veins of dogs and rabbits, and reproduced the clinical and postmortem findings which they had found in the women studied.

It is postulated that the amniotic fluid contents gain entrance to the maternal circulation by way of uterine sinuses or lacerated endocervical veins. The latter become ruptured as the cervix dilates and give rise to the bloody show. In every reported case, the membranes were ruptured prior to delivery. It has also been thought that powerful uterine contractions with possible small tears at the margin of the placenta are predisposing factors. However, premature separation of the placenta has not been a finding in the cases described.

Clinically, the patients are usually somewhat older than average and multiparous. Labor has been hard in the severe cases. The fetus may be dead or excessively large, but may also be perfectly normal. During labor, parturition, or the early postpartum period, the patient begins to cough, may feel nauseated and vomit. Anxiety, restlessness, chills and dyspnea are followed shortly by hypotension, tachycardia, and cyanosis. The physical findings of pulmonary edema are present. There is often a cough productive of frothy pink sputum. In the fatal cases, the patient goes into irreversible shock. Patients who survive the initial embolic episode may develop a bleeding tendency after several hours due to defibrination of the blood by the amniotic fluid. In nonfatal cases, the symptoms have varied in severity, with differing degrees of

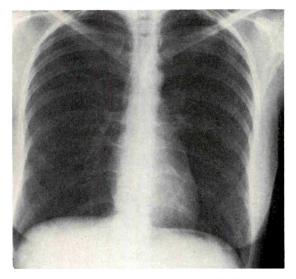


Fig. 3. Five months after delivery. The lungs are clear and the heart is back to nonpregnant state.

shock and often complete absence of bleeding tendency. The severity of the symptoms is undoubtedly related to the degree of embolization. Pulmonary edema has been observed in every instance.

Roentgenograms of the chest show massive perihilar infiltration which clears gradually over a period of several days. The appearance is indistinguishable from pulmonary edema due to other causes. The rate of clearing depends on the severity of the initial embolic episode.

Treatment is supportive and should include administration of oxygen, digitalization, antibiotic coverage, and possibly antispasmodics.

The radiologist who is aware of this condition should be able to make a definite contribution to correct diagnosis in non-fatal cases.

#### SUMMARY

- 1. A nonfatal case of amniotic pulmonary embolism is described.
  - 2. The pathologic, clinical, and roent-

genographic features are discussed.

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## SPONTANEOUS SUBCUTANEOUS EMPHYSEMA DURING LABOR\*

By GAYLORD S. KNOX, M.D. OKLAHOMA CITY, OKLAHOMA

AIR in the subcutaneous tissues is an interesting and unusual complication of labor. Two cases, occurring within days of each other in a small U.S. Army Station Hospital, prompted a search of the available literature for more information regarding this entity.

The most recent definitive article on the occurrence of respiratory emphysema in labor that could be located is that of Gordon<sup>8</sup> in which he reviewed "world literature" back to 1617, including original sources. He was able to collect 128 cases and added 2 of his own. Since then there have been several case reports, mostly in non-English literature, bringing the total to 187.

Subcutaneous and mediastinal emphysema is, of course, observed in many other conditions: measles, whooping cough, wounds of the lungs, tracheostomy wounds, foreign bodies in the lungs, in association with pulmonary interstitial emphysema, even with blowing the nose. As a spontaneous—i.e., unassociated with specific trauma, rupture of the uterus, gas-bacillus infections, etc.—complication of labor, it is unusual, and the 2 following cases were thought worthy of publication.

#### REPORT OF CASES

Case I. D.P., a 17 year old white primigravida was admitted to the U. S. Army Hospital, Bad Cannstatt, Germany, on August 6, 1961, in labor. Her prenatal course had been uncomplicated. The admission examination was normal and labor was progressive. Delivery was by low-forceps, but the patient sustained a third degree laceration of the pelvic floor which was repaired on the delivery table. The infant was a normal 3,330 gm. female.

When the patient was returned to the re-

covery room, it was noted that her voice was "peculiar" and that her neck was swollen. The next morning, although the patient was in no distress, subcutaneous emphysema was noted over her neck, shoulders, and anterior chest wall. No cardiac "crunch" was heard. Roentgenographic studies (Fig. 1 and 2) showed subcutaneous and mediastinal emphysema. The patient remained afebrile; the emphysema gradually subsided, and was gone when the patient was discharged on August 15, 1961.

Case II. A.S., a 21 year old white primigravida was admitted to the U.S. Army Hospital, Bad Cannstatt, Germany, on August 15, in active labor. Her prenatal course had been complicated by very mild preeclamptic toxemia and slight anemia. These were controlled by

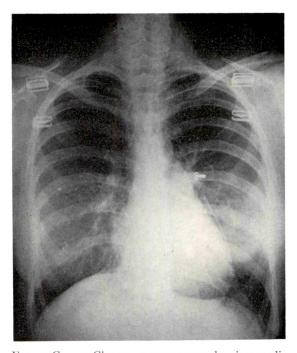


Fig. 1. Case 1. Chest roentgenogram showing mediastinal emphysema and cervical subcutaneous emphysema.

<sup>\*</sup> From the Department of Radiology, The University of Oklahoma Medical Center, Oklahoma City, Oklahoma.

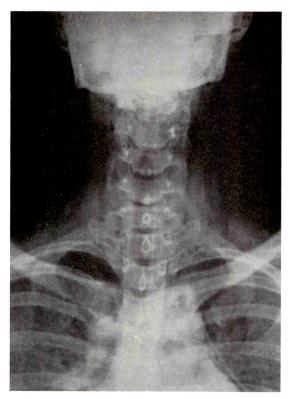


Fig. 2. Case I. Closeup of cervical spine showing the air in the soft tissues.

diet and medications. The admission examination showed a borderline hypertension (blood pressure 122/96). Delivery of a normal 3,350 gm. male infant was spontaneous with LML episiotomy.

A change in her voice was noticed on the delivery table, and by the time she was returned to the recovery room, subcutaneous emphysema of the neck, face, and shoulders was evident. Roentgenograms showed subcutaneous and mediastinal emphysema (Fig. 3). The next morning emphysema of the face, neck, shoulders and anterior chest wall was noted. However, aside from some anxiety regarding her appearance, the patient was in no distress. The emphysema gradually subsided and in 2 weeks was gone.

#### DISCUSSION

It is interesting to note that in both of these cases the first manifestation of subcutaneous emphysema was a change in voice quality. In neither case was the patient in distress at any time and in both cases no specific therapy was considered.

Gordon<sup>8</sup> states that the first recorded case was reported by Simmons in 1783; however, Louise Bourgeois, midwife to the Queen of France, may have referred to it when she wrote in her "Observations" in 1617: "I saw that she tried to stop crying out, and I implored her not to stop for fear that her throat would swell."

Most cases occur in young, robust primiparae and seem to be without predisposing causes, although dystocia is common. A hard, long labor, rigid soft parts, poor position of vertex, or a slowly-dilating cervix are reported.

Subcutaneous emphysema is usually observed during the second stage of labor, though frequently not noticed until the delivery is completed.

Hamman<sup>9</sup> feels that mediastinal emphysema is almost invariably present in cases

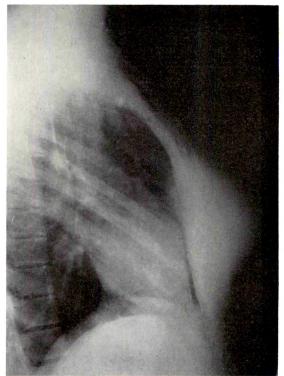


Fig. 3. Case II. Lateral chest roentgenogram showing air in the mediastinum as well as in the soft tissue of the chest wall. Note that some air has dissected downward into the preperitoneal structures anterior to the liver.

TABLE I

CAUSES OF PULMONARY INTERSTITIAL EMPHYSEMA

- 1. Trauma
  - A. Injury to chest with or without fracture of ribs
  - B. Operations on the chest, particularly the induction of pneumothorax
- 2. Increase of intrapulmonary pressure
  - A. Straining with the glottis closed

Heavy lifting

Straining at stool Childbirth

Attempts to resuscitate the newborn

B Occlusion, partial or complete, of the trachea or bronchi, usually accompanied by cough Anesthesia, especially when the closed

method or inflation method is used

Asthma

Bronchitis

Foreign body

Whooping cough

Pneumonia

3. Spontaneous rupture of alveoli

such as these, although it may not be clinically apparent. He feels that the sequence of events is: rupture of interstitial alveolus, pulmonary interstitial emphysema, mediastinal emphysema caused by dissection along the perivascular areolar tissue, and subcutaneous emphysema caused by dissection up the mediastinum through the thoracic inlet. He lists the causes of pulmonary interstitial emphysema (see Table 1). Any one of these may result in mediastinal emphysema. Air then may be confined to the mediastinum (when grave clinical signs and symptoms may result, depending upon the amount of air and the degree of increased mediastinal pressure), or the air may escape in any one of three pathways: (1) into the subcutaneous and deep tissues of the neck, (2) through the diaphragm, about the aorta and esophagus, and (3) into the pleural cavities, where the association of pneumomediastinum and pneumothorax is an intimate one.

Diagnosis of subcutaneous emphysema offers no difficulties, though the appearance of the patient may be startling or the swelling mistaken, on observation, for edema. The presence of the crackling air crepitation is characteristic. The chest and

cervical roentgenograms are diagnostic.

Treatment is expectant, although analgesics may occasionally be necessary for pain. Rarely is surgical decompression of the mediastinum needed for progressive mediastinal emphysema with its circulatory and respiratory complications.

#### SUMMARY

Air in the subcutaneous tissues is an interesting and unusual complication of labor. A total of 187 cases was found in the literature and 2 more cases are reported. The mechanisms involved in the production of subcutaneous emphysema are briefly discussed.

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# THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

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Forty-fifth Annual Meeting: Mark Hopkins Hotel, San Francisco, Calif., April 1-4, 1963.

### ≈ E D I T O R I A L S 🛰

### AUTOSOMAL TRISOMY SYNDROMES

THE phenomenal advances made during the last few years in the completely new field of cytogenetic analysis of the human chromosomes are of particular aid in interpreting certain developmental anomalies described in the pediatric radiologic literature as syndromes under various names. Rapid improvement in tissue culture techniques and unexpected biologic refinements in preparing chromosomes in somatic cells for morphologic study are bringing to light the intriguing fact that specific congenital anomalies might be correlated with specific autosomal chromosome abnormalities.

It had long been accepted that the normal human chromosome number was 48. However, in 1956 Tjio and Levan¹ and Ford and Hamerton² independently discovered that the correct number is 46, consisting of 22 pairs of autosomes and 1 pair of sex chromosomes (X and Y). Following this discovery and the definition of the normal human karyotype in 1958 by Ford, Jacobs and Lajtha,³ publication of a remarkable series of anomalies began to appear in the literature. Carr,⁴ in an excellent review of these anomalies, broadly places them in 2 categories: sex chromosome anomalies and autosomal anomalies.

The most common of the sex chromosome anomalies with 47 chromosomes are the Klinefelter syndrome including an XXY complex and some other variants (XXYY, XXXY, and XXXXY), and the

Turner's syndrome or gonadal dysgenesis, with the XO or XX complex.

The autosomal anomalies are the result of the presence of a third chromosome in one of the pairs of the autosomes (trisomy), so that the total number of chromosomes in the karyotype of the affected individual is likewise 47. The three autosomal trisomies known at the present time are: trisomy 21 or mongolism, with a small acrocentric chromosome in 21; trisomy 13–15 or D<sub>1</sub> syndrome, with a large acrocentric chromosome in 13–15; and trisomy 17–18 or E syndrome, with a medium sized acrocentric chromosome in 17–18.

Mongolism or Down's syndrome, perhaps the most frequent of all congenital anomalies in man, was linked to the group of autosomal trisomies in 1959 by Lejeune, Turpin and Gautier, who described it as the first example of human "autosomic aberration." Since then additional investigators confirmed this finding, and it is now accepted that mongolism is invariably associated with at least partial trisomy, probably of chromosome 21. However, in view of the fact that several cases have been described in the literature with the presence of trisomy 21 but without stigmata of mongolism, Carr raises the question whether the extra chromosome is number 22, a fragment of some other member in the normal complement, or a supernumerary chromosome.

The trisomy 13–15 syndrome was first described in 1960 by Patau, Smith, Therman, Inhorn and Wagner.<sup>6</sup> This original re-

 $<sup>^1</sup>$  TJ10, J. H., and Levan, A. Chromosome number of man. Hereditas, 1956, 42, 1–6.

<sup>&</sup>lt;sup>2</sup> Ford, C. E., and Hamerton, J. L. Chromosomes of man. *Nature*, 1956, 178, 1020–1023.
<sup>3</sup> Ford, C. E., Jacobs, P. A., and Lajtha, L. G. Human

<sup>&</sup>lt;sup>3</sup> FORD, C. E., JACOBS, P. A., and LAJTHA, L. G. Human somatic chromosomes. *Nature*, 1958, 181, 1565–1568.

<sup>&</sup>lt;sup>4</sup> Carr, D. H. Chromosomal abnormalities and their relation to disease. *Canad. M. A. J.*, 1963, 88, 456-461.

<sup>&</sup>lt;sup>5</sup> LEJEUNE, J., TURPIN, R., and GAUTIER, M. Mongolisme, premier example d'aberration autosomique humaine. *Ann. genet.*, 1959, 7, 41–49.

<sup>&</sup>lt;sup>6</sup> Patau, K., Smith, D. W., Therman, E. Inhorn, S. L., and Wagner, H. P. Multiple congenital anomaly caused by extra autosome. *Lancet*, 1960, 7, 790–793.

port was followed by several additional reports by the same authors, as well as by similar publications from other investigators. Very recently Smith, Patau, Therman, Inhorn and DeMars<sup>7</sup> reviewed the entire material, and, using as a basis 7 cases of their own and 7 collected from the literature, established the principal pattern of anomalies in this syndrome. This pattern, although the combination of anomalies and their degree of expression may vary from case to case, includes: apparent mental retardation; apparent deafness; breath-holding (apneic spells) and/or seizures; microphthalmia and/or harelip; hyperconvex narrow fingernails; polydactyly; hemangiomas and cardiac defects. There may be other less specific anomalies. As in mongolism, the incidence of the syndrome increases greatly with advancing maternal age.

As stated, the basic chromosome number in this syndrome is 47. There is an extranumerary chromosome in the D group, which comprises the chromosomes 13–15, and since present techniques do not enable individual identification of these chromosomes, the name D syndrome is often used for trisomy 13-15. The term "D1 trisomy" was coined by Therman and associates;8 however, it now appears likely that  $D_1$  is not merely the first D chromosome for which trisomy 13-15 was described but, considering the high early mortality in this syndrome, the only one without lethal effect before birth.7 It remains to be seen whether the study of abortions and stillbirths will lead to discovery of prenatal D<sub>2</sub> and D<sub>3</sub> trisomy syndromes.

Smith and his colleagues<sup>7</sup> also made an interesting perusal of the older literature for probable trisomy D<sub>1</sub> cases, which were described under different syndromes. Their retrospective analysis goes back to the days of Kundrat, who in 1882 published a

<sup>7</sup> SMITH, D. W., PATAU, K., THERMAN, E., INHORN, S. L., and DEMARS, R. I. D<sub>1</sub> trisomy syndrome. J. Pediat., 1963, 62, 326–341.

monograph on the arrhiencephaly syndrome which, in fact, depicts the striking pattern of anomalies characteristic of the D<sub>1</sub> trisomy syndrome. The same may be said of some of the cases of arrhiencephaly published more recently by Yakovlev and of several cases reported under the heading of typus rostockiensis.

The last of the three known autosomal trisomy syndromes, the trisomy 17–18, was described in 1960 by Edwards et al.9 and Smith et al. 10 independently. As regards the accurate identification of the locus of the extra chromosome, the situation is identical to that seen in trisomy 13-15. Therefore, the term of E syndrome is frequently used, indicating that the supernumerary acrocentric chromosome is in group E, comprising chromosomes 17-18. Several impressive reports appeared on this subject lately; and in this issue of the JOURNAL, Moseley, Wolf and Gottlieb<sup>11</sup> give an excellent account of the significance of this syndrome. They list the most constant abnormalities as follows: low set, misshapen ear; receding chin; small triangular mouth; shield-like chest; hypertonia; abnormalities of the fingers and toes; and cardiac malformations which regularly include interventricular septal defect and patent ductus arteriosus. The duration of life in the cases reported has ranged from 2 days to 16 months.

Koening, Lubs and Brandt,<sup>12</sup> in an authoritative appraisal of the specificity of the three autosomal trisomies, arrived at the conclusion that a certain number of anomalies are specific of the particular syndrome but that others are common to all three syndromes. The specific features of mongolism are well known. Those of tri-

10 SMITH, D. W., PATAU, K., THERMAN, E., and INHORN, S. L. New autosomal trisomy syndrome: multiple congenital anomalies caused by extra chromosome. *J. Pediat.*, 1960, *57*, 338–345.

11 Moseley, J. E., Wolf, B. S., and Gottlieb, M. I. Trisomy

<sup>11</sup> Moseley, J. E., Wolf, B. S., and Gottlieb, M. I. Trisomy 17–18 syndrome; roentgen features. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1963, 80, 905–913.

THERAPY & NUCLEAR MED., 1963, 89, 905–913.

12 KOENING, E. U., LUBS, H. A., JR., and BRANDT, I. K. Relationship between congenital anomalies and autosomal chromosome abnormalities. Yale J. Biol. & Med., 1962, 35, 189–205.

<sup>341.

8</sup> THERMAN, E., PATAU, K., SMITH, D. W., and DEMARS, R. I. D trisomy syndrome and XO gonadal dysgenesis in two sisters. Am. J. Human Genet., 1961, 13, 193–204.

<sup>&</sup>lt;sup>9</sup> Edwards, J. H., Harnden, D. G., Cameron, A. H., Crosse, V. M., and Wolff, O. H. New trisomic syndrome. *Lancet*, 1960, 1, 787–789.

somy 13–15 are: capillary hemangiomata; polydactyly; cleft palate; and eye defect. The specific features of trisomy 17–18 include: malformed ears; micrognathia; spacticity; malformed sternum; and probably polyhydramnios and dorsiflexion of the hallux. Such anomalies as mental retardation, low set ears, congenital heart defects (particularly interventricular septal defects) are found in all three trisomic syndromes as well as in children with normal chromosome patterns and are therefore not diagnostic.

Koening and co-workers found 4 instances of autosomal trisomies in 10 children with multiple anomalies. One case was of particular interest since clinically it was felt that this patient had the Pierre Robin syndrome with micrognathia and glossoptosis, but cytogenetic study revealed trisomy 17–18. It is, therefore, postulated that many cases termed Pierre Robin syndrome may be trisomy 17–18.

In addition to the three main autosomal trisomies considered above, other patterns have been described recently in which a third acrocentric chromosome has been found, but, because of lack of uniformity in the anomalies observed, no evaluation of their significance is as yet possible. According to Carr, ring chromosomes have also been reported in 4 patients without possible positive correlation, merely proving the frequent difficulties which arise in relating chromosomal abnormalities to certain signs or symptoms.

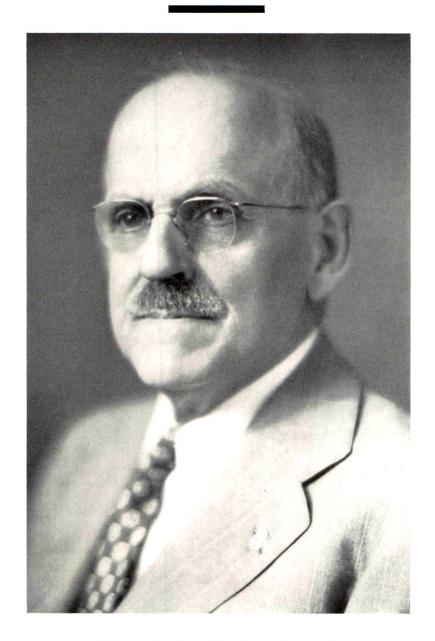
In the March, 1963 issue of the JOURNAL, Moore et al. 13 described karyotypes of bone cells of the normal human male, of cancer cells from an effusion of a male patient with cancer of the colon, and of bone marrow cells in a female patient after receiving I<sup>131</sup> therapy. A substantial number of these cells had 47 chromosomes, still further emphasizing the difficulties of interpretation. As Moore and his colleagues so aptly stated, "The era of cytogenetics is just beginning. . . . The future possibilities of such studies are unlimited."

T. LEUCUTIA, M.D.

Harper Hospital Detroit 1, Michigan

<sup>13</sup> Moore, G. E., Ishihara, T., Koepf, G. F., and Sandberg, A. A. Importance to radiologists of recent advances in cytology and cytogenetics. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1963, 89, 584–589.





DR. EDWARD W. ROWE 1881–1963

**D**R. EDWARD W. ROWE of Lincoln, Nebraska, died on January 6, 1963, as a result of Parkinson's disease, which he had had for the past several years. He was born in Roberts, Illinois, on June 21, 1881, and moved to Nebraska in 1885. His father

was a Methodist minister, who served a number of pastorates in Nebraska during Dr. Rowe's youth. Dr. Rowe graduated from the University of Nebraska in 1903 and from Northwestern University Medical School in 1905.

Following his graduation from medical school he became a general practitioner in Wood River, Nebraska, for a period of three years. In 1908, Dr. Rowe and his wife moved to Lincoln, Nebraska, where he practiced for the next fifty years. During his first years in Lincoln, Dr. Rowe did general practice and surgery; however, in 1914 he joined a cousin, Dr. J. Stanley Welch, and Dr. H. J. Lehnhoff to form the Lincoln Clinic. From this time forth Dr. Rowe devoted his entire professional career to Radiology.

Dr. Rowe served as Chief of Staff of Bryan Memorial Hospital from its opening in 1926 to 1947, and as Chairman of the Department of Radiology from 1926 to 1953. He also served as consultant in Radiology at the Lincoln Veterans Hospital and the Lincoln State Hospital. In 1918, he became a member of the Radiological Society of North America and was its President in 1927. In addition, during his professional life he held the office of President in the following Societies: The Lancaster County Medical Society, The Nebraska State Medical Association, and The Nebraska State Radiological Society. He was a past chancellor of the American College of Radiology, a member of the American Roentgen Ray Society and for many years Medical Director for the Midwest Life Insurance Company. Dr. Rowe believed a physician should be an active citizen who gives time and leadership to the affairs of the community and his church. He was a member of the Trinity Methodist Church and on its Board of Directors for

many years, a member of the Kiwanis Club, the Chamber of Commerce, the Masonic Lodge, the Scottish Rite and the Shrine. He served as President of the Lincoln Board of Education for seven years, was a member of the Lincoln Advisory Health Board and a Past Secretary for the State Board of Medical Examiners. For thirty years he was chairman of the Legislative Committee of the State Medical Association. The present Medical Practice Act in Nebraska was enacted during his tenure in this position. During World War I, he was Instructor at the Cornell Medical School of Roentgenology. Following this, he went overseas with the University of Nebraska Base Hospital, Number 49. He was on the Western Front during active warfare and after the Armistice spent the remaining two years with the Army of Occupation in Germany, being honorably discharged as a Major in August, 1919.

Dr. Rowe sought and taught the highest ideals in medical practice. He cherished the high attainments of American medicine and he constantly championed the American system of free enterprise. He was a leader in the fight against the ever encroaching tentacles of government in medicine. His teachings and his philosophy of life will long serve as an example for those who follow him. Surviving Dr. Rowe are his widow, Sarah Belle, one daughter, 3 grandchildren and 3 great grandchildren.

He will long be remembered by his friends as a teacher, medical leader and a kindly gentleman.

Maurice D. Frazer, M.D.



### **NEWS ITEMS**

# INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

The membership of the International Commission on Radiological Protection (ICRP) for 1962–1965 is as follows:

Chairman: Dr. E. Erich Pochin, United Kingdom.

Vice Chairman: Professor L. Bugnard, France.

Members: Mr. W. Binks, United Kingdom; Professor Otto Hug, Germany; Dr. H. Jammet, France; Dr. Bo Lindell, Sweden; Dr. John F. Loutit, United Kingdom; Dr. K. Z. Morgan, U.S.A.; Dr. H. J. Muller, U.S.A.; Professor Rolf M. Sievert, Sweden; Dr. C. Gordon Stewart, Canada; Professor R. S. Stone, U.S.A.; and Dr. Lauriston S. Taylor, U.S.A.

The Commission's secretariat has recently been transferred from Stockholm to the following address: Dr. F. D. Sowby, *Scientific Secretary*, Clifton Avenue, Sutton, Surrey, England.

# RADIOLOGICAL ASPECTS OF DISASTER PLANNING

A KIT FOR RADIOLOGISTS

The Committee on Radiological Aspects of Disaster Planning of the American College of Radiology under the co-chairmanships of Dr. G. M. McDonnel, Los Angeles, California, and Dr. John D. Reeves, Jr., Gainesville, Florida, prepared an extremely valuable kit on the radiation hazards and the precautions that should be taken under emergency conditions. This effort was jointly sponsored and financially supported by the American College of Radiology, The American Roentgen Ray Society and The Radiological Society of North America. Several pieces of material were furnished by the Division of Health Mobilization of the U. S. Public Health Service.

This kit is intended for the radiologist, with the aim of providing him with basic

information and highly authoritative data for local disaster planning programs. In addition, much of the material will be useful in evaluating peacetime radiological hazards and protection factors.

It is likely that this initial kit will be augmented with additional references from time to time.

Because of the continuing nature of the problem which it is hoped will be solved in part by this kit, contributions of new material are welcome for the Committee's review.

# THE ROCKY MOUNTAIN RADIOLOGIC CONFERENCE

The Twenty-fifth Annual Rocky Mountain Radiologic Conference will be held at the Denver Hilton Hotel, Denver, Colorado, on August 22, 23, and 24, 1963.

The guest Speakers include: Dr. J. E. Miller, Professor of Radiology, Baylor University Medical Center, Dallas, Texas; Dr. Benjamin Felson, Professor of Radiology, University of Cincinnati Medical School, Cincinnati, Ohio; and Dr. Walter T. Murphy, Director of Therapeutic Radiology, Roswell Park Memorial Institute, Buffalo, New York.

The Rocky Mountain Radiologic Society will honor Dr. Leo Rigler on Friday, the 23rd. This day will be dedicated to Dr. Rigler as eminent radiologist, beloved teacher and humanitarian. Twenty-three of Dr. Rigler's former pupils and associates will attend this meeting and present short papers of their choosing in honor of Dr. Rigler.

Additional information and programs can be obtained from Dr. John H. Freed, Secretary, Rocky Mountain Radiologic Society, 4200 E. 9th Avenue, Denver 20, Colorado.

#### TWELFTH IRA I. KAPLAN LECTURE

The Twelfth Ira I. Kaplan Lecture will be held on May 23, 1963 at 5 P.M. in the

main auditorium of the New York University College of Medicine.

The Guest Lecturer will be Dr. Henry L. Jaffe, Director of Laboratories at The Hospital for Joint Diseases. He will speak on The Roentgenopathologic Features of Paget's Disease of Bone and the Complication of Paget's Sarcoma.

# FIFTEENTH ANNUAL JOSEPH AND SAMUEL FREEDMAN LECTURES

Dr. Harold G. Jacobson, Professor of Clinical Radiology at the New York University College of Medicine and Chief, Division of Diagnostic Radiology, Montefiore Hospital, New York City, delivered the Fifteenth Annual Joseph and Samuel Freedman Lectures in Diagnostic Radiology. The meeting was held on Saturday and Sunday, April 27 and 28, 1963 at the University of Cincinnati College of Medicine.

# THE AMERICAN COLLEGE OF RADIOLOGY

RESIDENT WORKSHOPS IN SOCIO-ECONOMICS

As directed by the Board of Chancellors of the College, there is being planned a series of workshops for residents on the socio-economic aspects of radiology. The speakers will be individuals who are conversant with the subject matter listed. It is hoped and believed that the program will be of value to all men contemplating the practice of radiology as a career and of

indirect benefit to all currently in practice due to the information these young men will have made available to them.

The first of these workshops is planned for May 31–June 1, 1963 at the University of Tennessee College of Medicine in Memphis, Tennessee. Participants will include T. J. Wachowski, Wheaton, Illinois, President of ACR; David S. Carroll, Memphis, Tennessee, Chairman of the Board of Chancellors of ACR; Wallace D. Buchanan, South Bend, Indiana, Chairman of ACR Commission on Standards in Radiologic Practice; Drs. John E. Whiteleader, Benjamin E. Greenberg and William E. Long, all of Memphis, Tennessee; William C. Stronach, Executive Director of ACR and Otha W. Linton, Public Relations Director of ACR.

The second workshop will be conducted in Chicago, Illinois, Friday, June 7 (registration 1:00 p.m.) and Saturday, June 8, 1963 at the La Salle Hotel, with the cosponsorship of the Illinois Radiological Society, Chicago Roentgen Society, Indiana Roentgen Society, Iowa Radiological Society, Detroit Roentgen Ray and Radium Society and Wisconsin Radiological Society. If a choice need be made, second and third year residents should be given preference.

For further information please write to William C. Stronach, Executive Director, American College of Radiology, 20 North Wacker Drive, Chicago 6, Ill.



### BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

The Interpretation of Tomograms of the Head; An Atlas. By Marvin L. Daves, M.D., Assistant Professor, Department of Radiology, University of Colorado Medical Center, Denver, Colorado; and William E. Loechel, Director of Medical Illustration, Henry Ford Hospital, Detroit, Michigan. Cloth. Price, \$17.50. Pp. 248, with 172 illustrations. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Ill., 1962.

As the title indicates this book is an atlas. It is designed to illustrate normal anatomy as visualized on tomograms made in several commonly used projections. This has been accomplished by performing tomography on cadaver heads, slicing the specimens in the same planes as the tomograms and making roentgenograms of comparable slabs. Tomograms, roentgenograms, and illustrations of these slices are then labeled and compared.

Each of the four sections into which the book is divided deals with a separate plane: sagittal, coronal, basal and oblique. The format for each section is the same. A schematic drawing in a projection at right angles to the specified plane is first presented, illustrating the relative thickness of the slabs (about 2 mm.) and their relationship to each other (one every 5 mm.). Next, a roentgenogram of the head to be sectioned is compared with a clinical roentgenogram in the same projection. Following this, in consecutive groups of three, are a tomogram of the head before slicing, a regular roentgenogram of the corresponding slab after slicing, and an illustration of the same part.

Emphasis is placed on labeling the osseous structures. Vascular labeling is confined to vessels with contiguous demonstrable landmarks. Sufficient attention is given to neuroanatomy to make this volume helpful to the neurosurgeon and neurologist as well as to the radiologist.

HOWARD J. WEST, M.D.

Anatomy of the Coronary Arteries. By Thomas N. James, M.D., F.A.C.P., Chairman, Section on Cardiovascular Research, Henry Ford Hospital, Detroit, Michigan. Cloth. Price, \$18.00. Pp. 211, with 136 illustrations of which 42 are in color. Paul B. Hoeber, Inc., 49 East 33rd Street, New York 16, N. Y., 1961.

This excellent monograph presents a detailed study of the gross anatomy of the coronary arteries in man. The injection-corrosion method is employed, in which colored plastic materials are used to perfuse the vessels and chambers, followed by corrosion with hydrochloric acid. One hundred and six hearts have been examined by this method and comprise the basis for analysis.

Separate chapters are devoted to each artery and its major branches. Particular attention is directed to variations in course and distribution of the principal vessels; possible clinical complications, while not discussed in detail, are apparent. Venous anatomy is also well illustrated and a separate chapter describes arterial anastomoses in the normal heart with a limited discussion of changes that occur following coronary occlusion. The text is amplified by numerous photographs of the injected specimens, many of which are vividly displayed in color.

This book presents factual data which should be of interest to all physicians who are concerned with the problems of coronary artery disease.

DAVID P. CORBETT, M.D.

#### BOOKS RECEIVED

CLINICAL RADIOLOGY OF THE BILIARY TRACT. By William H. Shehadi, M.D., F.A.C.R., Director, Department of Radiology, The United Hospital, Port Chester, New York; Formerly, Professor and Director, Department of Radiology, The New York Polyclinic Medical School and Hospital, New York, New York. Cloth. Price, \$16.00. Pp. 305, with 181 illustrations. The Blakiston Division—McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., 1963.

The Anatomical Foundation of Neuroradiology of the Brain. By McClure Wilson, M.D., Associate Professor in Radiology, University of Texas Medical Branch, Galveston, Texas. Cloth. Price, \$12.50. Pp. 239, with 136 illustrations.

Little, Brown & Company, 34 Beacon Street, Boston 6, Mass., 1963.

Longmore's Medical Photography. Seventh revised edition. Edited by Peter Hansell, MRCS, Director, Departments of Photography and Illustration, Westminster Medical School and Institute of Ophthalmology, University of London, England; and Robert Ollerenshaw, TD, MA, Director, Departments of Medical Illustration, The Royal Infirmary, Manchester and Christie Hospital and Holt Radium Institute, Manchester, England. Cloth. Price, \$15.00. Pp. 544, with 135 illustrations. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa., 1962.

Washington Square, Philadelphia 5, Pa., 1962.
Gastroenterology. Vol. I. Second edition. By Henry L. Bockus, M.D., Emeritus Professor of Medicine, University of Pennsylvania School of Medicine; and Present and Former Colleagues at the University of Pennsylvania Graduate School of Medicine and School of Medicine. Cloth. Price, \$25.00. Pp. 958, with many illustrations. W. B. Saunders Company, West Washington Square, Philadelphia 5, Pa., 1963.

RADIOACTIVE ISOTOPES IN MEDICINE AND BIOLOGY.

Vol. I. Basic Physics and Instrumentation.
Second edition. By Edith H. Quimby, Sc.D.,
Professor Emeritus of Radiology, College of
Physicians and Surgeons, Columbia University,
New York; and Sergei Feitelberg, M.D., Director,
Andre Meyer Department of Physics, The Mount
Sinai Hospital; Assistant Clinical Professor of
Radiology (Physics), College of Physicians and
Surgeons, Columbia University, New York.
Cloth. Price, \$8.00. Pp. 343, with 84 illustrations.
Lea & Febiger, Washington Square, Philadelphia
6, Pa., 1963.

SARCOMAS OF THE BRAIN. By James W. Kernohan, M.D., D.P.H., Senior Consultant, Section of Pathologic Anatomy, Mayo Clinic, Professor of Pathology, Mayo Foundation, Graduate School, University of Minnesota; and Alfred Uihlein, M.D., Consultant, Section of Neurologic Surgery, Mayo Clinic, Associate Professor of Neurologic Surgery, Mayo Foundation, Graduate School, Uni-

versity of Minnesota, Rochester, Minn. Cloth. Price, \$8.00. Pp. 192, with 96 illustrations. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Ill., 1962.

RADIOGRAPHY OF INFANTS AND CHILDREN. By Donald B. Darling, M.D., Assistant Professor of Radiology, Tufts University School of Medicine and Boston University School of Medicine; Consultant Radiologist, Boston City Hospital, Boston, Mass. Cloth. Price, \$16.50. Pp. 193, with 229 illustrations. Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Ill., 1962.

THE YEAR BOOK OF RADIOLOGY (1962-1963 YEAR BOOK SERIES). RADIOLOGIC DIAGNOSIS. Edited by John Floyd Holt, M.D., Professor, Department of Radiology, University of Michigan; and Walter M. Whitehouse, M.D., Associate Professor, Department of Radiology, University of Michigan, Ann Arbor, Mich. RADIATION THERAPY. Edited by Harold W. Jacox, M.D., Professor of Radiology, College of Physicians and Surgeons, Columbia University; and Morton M. Kligerman, M.D., Professor of Radiology and Chairman of the Department of Radiology, Yale University School of Medicine. Cloth. Price, \$11.75. Pp. 435, with 334 illustrations. Year Book Medical Publishers, 35 East Wacker Drive, Chicago 1, Ill., 1963.

CARE OF THE PATIENT IN DIAGNOSTIC RADIOGRAPHY. By D. Noreen Chesney, Hon. F.S.R.T.E., Superintendent Teacher, School of Radiography, Covventry and Warwickshire Hospital; and Muriel O. Chesney, F.S.R. T.E., Teacher-Principal, School of Radiography, The United Birmingham Hospitals, Birmingham, England. Cloth. Price, \$5.50. Pp. 231, with 49 illustrations. F. A. Davis Company, 1914 Cherry Street, Philadelphia 3, Pa., 1962.

LASERS: GENERATION OF LIGHT BY STIMULATED EMISSION. By Bela A. Lengyel, Member of the Technical Staff, Hughes Research Laboratories, Malibu, California. Cloth. Price, \$6.95. Pp. 125, with 38 illustrations. John Wiley & Sons, 440 Park Avenue South, New York 16, N. Y., 1962.



### SOCIETY PROCEEDINGS

#### MEETINGS OF RADIOLOGICAL SOCIETIES\*

#### United States of America

AMERICAN ROENTGEN RAY SOCIETY

Secretary, Dr. C. Allen Good, Mayo Clinic, Rochester, Minn. Annual meeting: Queen Elizabeth Hotel, Montreal, Que., Canada, Oct. 8-11, 1963.

American Radium Society

Secretary, Dr. Justin J. Stein, U.C.L.A. Medical Center, Los Angeles 24, Calif. Annual meeting: Mark Hopkins Hotel, San Francisco, Calif., April 1–4, 1963.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Secretary, Maurice Doyle Frazer, 1744 South Fifty-

eighth St., Lincoln, Neb. Treasurer, Dwight Vincent Needham, 713 E. Genessee St., Syracuse, N. Y. Annual meeting: Palmer House, Chicago, Ill., Nov. 17–22, 1963.

AMERICAN COLLEGE OF RADIOLOGY

Executive Director, William C. Stronach, 20 N. Wacker Drive, Chicago 6, Ill. Annual meeting: Ramada Inn, Tucson, Ariz., Feb. 5-8, 1964.

Section on Radiology, American Medical Association Secretary, Dr. Clyde A. Stevenson, Sacred Heart Hospital, West 101 Eighth Ave., Spokane 4, Wash. Annual meeting: Atlantic City, N. J., June 16–20, 1963.

AMERICAN BOARD OF RADIOLOGY

Secretary, Dr. H. Dabney Kerr. Correspondence should be directed to Kahler Hotel Building, Rochester, Minn. The Spring 1963 examination will be held at the Sheraton Hotel, Philadelphia, Pennsylvania, June 3-7, inclusive. Deadline for filing applications was December 31, 1962. There will be a Special Examination in Nuclear Medicine for diplomates in Radiology or Therapeutic Radiology if sufficient applications are received. The Fall 1963 examination will be held at the Terrace Hilton Hotel, Cincinnati, Ohio, December 2-6, inclusive. Deadline for filing applications is June 30, 1963.

AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE Secretary-Treasurer, Charles S. Simons, University of Michigan Hospital, Ann Arbor, Mich. Annual meeting to be announced.

AMERICAN CLUB OF THERAPEUTIC RADIOLOGISTS

Secretary, Dr. J. A. del Regato, Penrose Cancer Hospital, Colorado Springs, Colo.

ELEVENTH INTERNATIONAL CONGRESS OF RADIOLOGY Secretary-General, Professor Dr. Med. Arduino Ratti, via Moscova, 44-1, Milan, Italy. Address inquiries to Professor Dr. Med. Luigi Turano, President-Elect, Istituto di Radiologia, Università di Roma, Rome, Italy. Meeting: September, 1965.

Eighth Inter-American Congress of Radiology Counselor for the United States, Dr. Philip J. Hodes, Jefferson Medical College Hospital, 11th and Walnut Streets, Philadelphia 7, Pennsylvania. Secretary, Dr. Mario Gaitan-Yanguas, Bogotá, Colombia.

Meeting to be announced. ALABAMA RADIOLOGICAL SOCIETY

Secretary, Dr. Walter Brower, Birmingham, Ala. Meets time and place of Alabama State Medical Association.

AMERICAN NUCLEAR SOCIETY

Treasurer, Raymond Maxson, 86 E. Randolph St., Chicago, Ill. Annual Meeting: Salt Lake City, Utah, June 17-19, 1963.

ARIZONA RADIOLOGICAL SOCIETY

Secretary, Dr. E. Lawrence Ganter, 1820 E. Polk St.,

Phoenix 34, Ariz. Two regular meetings a year. Annual meeting at time and place of State Medical Association and interim meeting six months later.

ARKANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Charles W. Anderson, 11081 Poplar, Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

Association of University Radiologists

Secretary, Dr. John A. Campbell, Indiana University Medical Center, Indianapolis, Ind. Annual meeting: Yale University Medical Center, New Haven, Conn., May 24-25, 1963.

ATLANTA RADIOLOGICAL SOCIETY

Secretary, Dr. Wilson T. Edenfield, 35 Linden Ave., N.E., Atlanta 8, Ga. Meets monthly, except during three summer months, on second Friday evening.

BLOCKLEY RADIOLOGICAL SOCIETY

Secretary, Dr. Bernard J. Ostrum, 2412 North 52nd St., Philadelphia, Pa.

BROOKLYN RADIOLOGICAL SOCIETY

Secretary, Dr. Peter J. Lampros, 121 Dekalb Ave., Brooklyn, N. Y. Meets first Thursday of each month October through May.

BUFFALO RADIOLOGICAL SOCIETY

Secretary, Dr. Edward A. Dunlap, Jr., 35 Danbury Lane, Kenmore 17, N. Y. Meets second Monday evening each month, October to May inclusive.

CALIFORNIA RADIOLOGICAL SOCIETY

Secretary, Dr. L. Henry Garland, Suite 1739, 450 Sutter St., San Francisco, Cal. Meets annually during meeting of California Medical Association.

CENTRAL NEW YORK RADIOLOGICAL SOCIETY

Secretary, Dr. Edward W. Carsky, Crouse-Irving Hospital, 820 S. Crouse Ave., Syracuse, N. Y. Meets first Monday each month October through May.

CENTRAL OHIO RADIOLOGICAL SOCIETY

Secretary, Dr. Dana R. Schmidt, 1500 West Third Ave., Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, November, January, March and May at Fort Hayes Hotel, Columbus, Ohio.

CENTRAL SOCIETY OF NUCLEAR MEDICINE

Secretary, Dr. Robert S. Landauer, Radiation Center Bldg., 1903 West Harrison St., Chicago 12, Ill.

CHICAGO ROENTGEN SOCIETY

Secretary, Dr. Abram Cannon, Chicago Wesley Memorial Hospital, 250 E. Superior St., Chicago 11, Ill. Meets second Thursday of each month, October to April except December at the Pick-Congress Hotel at 8:00 P.M.

CLEVELAND RADIOLOGICAL SOCIETY

Secretary, Dr. Ward D. Heinrich, Huron Road Hospital. Cleveland 12, Ohio. Meetings at 7:00 P.M. on fourth Monday of October, November, January, February, March and April.

Colorado Radiological Society

Secretary, Dr. Seward Imes, 1845 High St., Denver, Colo. Meets third Friday of each month at Denver Athletic Club from September through May.

Connecticut Valley Radiologic Society

Secretary, Dr. James L. Krieger, 85 Jefferson St., Hartford 6, Conn. Meets first Friday in February and April. DALLAS-FORT WORTH RADIOLOGICAL SOCIETY

Secretary, Dr. Robert D. Moreton, 816 Medical Arts Bldg., Fort Worth, Tex. Meets monthly, third Mon-day, at Greater Fort Worth International Airport at 6:30

<sup>\*</sup> Secretaries of societies are requested to send timely information promptly to the Editor.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY Secretary, Dr. Arch H. Hall, Harper Hospital, Detroit 1. Mich. Meets monthly, first Thursday, October through May, at David Whitney House, 1010 Antietam, at 6:30 P.M.

EAST BAY ROENTGEN SOCIETY

Secretary, Dr. Dan Tucker, 434 30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland, Calif.

EAST TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. J. Marsh Frere, Jr., 205 Medical Arts Bldg., Knoxville, Tenn. Meets in January and September.

EASTERN CONFERENCE OF RADIOLOGISTS

Secretary, Arrangements Committee, Dr. Theodore A Tristan, 3400 Spruce St., Philadelphia 4, Pa. Annual meeting: April 4-6, 1963, Philadelphia, Pa.

EASTERN RADIOLOGICAL SOCIETY

Secretary, Dr. James F. Martin, North Carolina Baptist Hospital, Winston-Salem, N. C.

FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. Marvin V. McClow, St. Vincent's Hospital, Barrs and St. Johns Ave., Jacksonville 4, Fla. Meets twice annually, in the spring with the annual State Society Meeting and in the fall.

FLORIDA WEST COAST RADIOLOGICAL SOCIETY

Secretary-Treasurer, Dr. Garth R. Drewry, Tampa General Hospital, Tampa 6, Fla. Meets in January, April, July and October.

GEORGIA RADIOLOGICAL SOCIETY

Secretary, Dr. George W. Brown, Griffin, Ga. Meets in spring and fall with Annual State Society Meeting.

Greater Miami Radiological Society

Secretary, Dr. Robert F. Feltman, Dade County Medical Association Building, Two S.E. Thirteenth St., Miami Association Building, Two S.E. Thirteenth St., Miami 32, Fla. Meets monthly, third Wednesday at 8:00 P.M. at Jackson Memorial Hospital, Miami, Fla. GREATER ST. LOUIS SOCIETY OF RADIOLOGISTS

Secretary, Dr. C. M. Witt, #16 Hampton Village Plaza, St. Louis 9, Mo.

HOUSTON RADIOLOGICAL SOCIETY

Secretary, Dr. W. A. Goodrich, Jr., Texas Medical Center Library, Jesse H. Jones Library Bldg., Houston 25, Tex. Meets fourth Monday of each month, except June, July, August and December, at the Doctors' Club, 8:00 P.M., Houston, Tex.

IDAHO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. George H. Harris, Bannock Memorial Hospital, Pocatello, Idaho. Meets in the spring and fall.

ILLINOIS RADIOLOGICAL SOCIETY

Secretary, Dr. George A. Miller, Carle Hospital Clinic, Urbana, Ill. Meets in the spring and fall.

Indiana Roentgen Society, Inc.
Secretary, Dr. Richard A. Silver, 712 Hume Mansur Bldg., Indianapolis, Ind. Meets first Sunday in May and during fall meeting of Indiana State Medical Association.

IOWA RADIOLOGICAL SOCIETY

Secretary, Dr. L. L. Maher, 1419 Woodland Ave., Des Moines, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. The scientific section is held in the autumn.

KANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Roger K. Wallace, Riley County Hospital, Manhattan, Kan. Meets in spring with State Medical Society and in winter on call.

KENTUCKY RADIOLOGICAL SOCIETY

Secretary, Dr. Lawrence A. Davis, 226 East Chestnut St., Louisville, Ky. Meets monthly on second Friday at Sheraton Hotel, Louisville.

KINGS COUNTY RADIOLOGICAL SOCIETY

Secretary, Dr. Abraham Berens, 1917 Bedford Ave., Brooklyn 25, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

KNOXVILLE RADIOLOGICAL SOCIETY

Secretary, Dr. Clifford L. Walton, Blount Professional Bldg., Knoxville 20, Tenn. Meetings are held the third Monday of every other month at the University of Tennessee Memorial Research Center and Hospital.

Los Angeles Radiological Society

Secretary, Dr. Chester P. Bonoff, 1930 Wilshire Blvd., Los Angeles 57, Cal. Meets second Wednesday of month in September, November, January, March and June at Los Angeles County Medical Association Building, Los Angeles.

MAINE RADIOLOGICAL SOCIETY

Secretary, Dr. Charles W. Capron, Maine Medical Center, Portland, Me. Meets in June, September, December and April.

MARYLAND RADIOLOGICAL SOCIETY

Secretary, Dr. James A. Lyon, Jr., 7918 Springway Rd., Ruxton 4, Maryland. Memphis Roentgen Society

Secretary, Dr. Irving K. Ettman, Kennedy V.A. Hospital, Department of Radiology, Memphis 15, Tenn. Meets first Monday of each month at John Gaston Hospital.

MIAMI VALLEY RADIOLOGICAL SOCIETY

Secretary, Dr. William D. Roberts, 2197 Los Arrow Dr., Dayton 9, Ohio. Meets second Friday of fall and winter months.

MID-HUDSON RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph Sorrentino, St. Francis Hospital, Poughkeepsie, N. Y. Meets 8:30 P.M., fourth Wednesday of each month September to May.

MILWAUKEE ROENTGEN RAY SOCIETY

Secretary, Dr. Abraham Marck, Mayfair Professional Bldg., Milwaukee 13, Wis. Meets monthly on fourth Monday, October through May, at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Frank J. Anderson, 810 E. 27th St., Minneapolis 7, Minn. Meets three times annually, in fall, winter and spring.

Mississippi Radiological Society

Secretary, Dr. Jack K. Goodrich, University Medical Center, Jackson, Miss. Meets third Thursday of each month at the Heidelberg Hotel, Jackson, at 6:00 P.M.

MONTANA RADIOLOGICAL SOCIETY

Secretary, Dr. John M. Fritts, 1224 S. Higgins Ave., Missoula, Montana. Meets at least once a year.

NASSAU RADIOLOGICAL SOCIETY

Secretary, Dr. Herbert Kantor, 71 S. Oyster Bay Rd., Syosset, N. Y. Meets second Tuesday of the month in February, April, June, October and December. Nebraska State Radiological Society

Secretary, Dr. Richard Bunting, The Radiologic Center, Nebraska Methodist Hospital, Omaha 31, Neb. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEVADA RADIOLOGICAL SOCIETY

Secretary, Dr. William G. Arbonies, Department of Radiology, St. Mary's Hospital, Reno, Nev.

NEW ENGLAND ROENTGEN RAY SOCIETY

Secretary, Dr. Robert E. Wise, 605 Commonwealth Ave., Boston 15, Mass. Meets third Friday of each month, October through April, at The Longwood Towers, Brookline, Mass. at 4:30 P.M.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY

Secretary, Dr. Paul Y. Hasserjian, 1470 Elm St., Manchester, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY

Secretary, Dr. James J. Nickson, Memorial Hospital, New York, N. Y. Meets monthly on third Monday at the New York Academy of Medicine at 4:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. Simmons J. Patrick, Lenoir Memorial Hospital, Kinston, N. C. Meets in the spring and fall each vear.

NORTH DAKOTA RADIOLOGICAL SOCIETY

Secretary, Dr. John Jestadt, Depuy-Sorkness Clinic,

Jamestown, N. D. Meets at time of State Medical Association meeting. Other meetings arranged on call of the President.

NORTH FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. Charles H. Newell, 800 Miami Road,
Jacksonville 7, Fla. Meets quarterly in March, June,
September and December.

NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY

Secretary, Dr. Anthony J. Tabacco, 621 Central Ave., Albany 6, N. Y. Meets in Albany area on second Wednesday of October, November, March and April. NORTHERN CALIFORNIA RADIOLOGICAL SOCIETY

Secretary, Dr. Rob H. Kirkpatrick, 1219 28th St., Sacramento, Calif. Meets at dinner last Monday of each month, September to June.

Northwestern Ohio Radiological Society Secretary, Dr. Anthony F. Lalli, 421 Michigan St.,

Toledo, Ohio.

Ohio State Radiological Society

Secretary, Dr. Chapin Hawley, 927 Carew Tower, Cincinnati 2, Ohio. Annual meeting: Dayton, Ohio, May, 1963.

Oklahoma State Radiological Society

Secretary, Dr. Simon Pollack, Utica Square Medical Center, Tulsa, Okla. Meets in January, May and October.

Orange County Radiological Society

Secretary-Treasurer, Dr. E. Nicholas Sargent, Orange
County General Hospital, Orange, Calif. Meets fourth Tuesday of month except June, July, August and December in Orange County Medical Association Build-

OREGON RADIOLOGICAL SOCIETY

Secretary, Dr. James A. Schneider, St. Vincent Hospital, Portland 10, Ore. Meets monthly from October to June on the second Wednesday of each month at 8:00 P.M. at the University Club.

ORLEANS PARISH RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets second Tuesday of each month.

Pacific Northwest Radiological Society Secretary, Dr. Charles E. Donley, 543 East 4th Street, Bend, Ore. Annual meeting: The Bayshore Inn, Van-

couver, B. C., May 10–12, 1963. Pennsylvania Radiological Society

Secretary, Dr. Frederick R. Gilmore, Clearfield Hospital, Clearfield, Pa. Annual meeting: Bedford Springs Hotel, May 23-25, 1963.

PHILADELPHIA ROENTGEN RAY SOCIETY

Secretary, Dr. Antolin Raventos, 3400 Spruce St., Philadelphia 4, Pa. Meets first Thursday of each month at 5 P.M., from October to May in Thompson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY

Secretary, Dr. Marvin Brodie, 3459 Fifth Ave., Pittsburgh 13, Pa. Meets second Wednesday of month, October through June at Park Schenely Restaurant.

RADIOLOGICAL SOCIETY OF GREATER CINCINNATI

Secretary, Dr. Richard B. Mulvey, 2421 Auburn Ave., Cincinnati, Ohio. Meets first Monday of each month at Cincinnati Academy of Medicine.

RADIOLOGICAL SOCIETY OF HAWAII
Secretary, Major Carl W. Boyer, Jr., U. S. Army Tripler General Hospital, Honolulu, Hawaii. Meets third Monday of each month at 7:30 P.M.

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY Secretary, Dr. J. Stewart Whitmore, 1010 Rialto Bldg., Kansas City, Mo. Meets last Friday of each month.

RADIOLOGICAL SOCIETY OF KANSAS CITY Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

RADIOLOGICAL SOCIETY OF LOUISIANA

Secretary, Dr. Andrew F. Giesen, Ochsner Clinic, New Orleans 15, La. Meets annually during Louisiana State Medical Society meeting. RADIOLOGICAL SOCIETY OF NEW JERSEY

Secretary, Dr. E. Arthur Kratzman, 912 Prospect Ave., Plainfield, N. J. Meets in Atlantic City at time of State Medical Society meeting and in October or November in Newark, N. J.

RADIOLOGICAL SOCIETY OF THE STATE OF NEW YORK Secretary-Treasurer, Dr. John W. Colgan, 273 Hollywood Ave., Rochester 18, N. Y. Annual meeting to be announced.

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA

Secretary-Treasurer, Dr. Donald J. Peik, 303 S. Minnesota Ave., Sioux Falls, S. D.

RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA Secretary, Dr. Richard P. Storrs, 2131 West Third, Los Angeles, Calif.

REDWOOD EMPIRE RADIOLOGICAL SOCIETY
Secretary, Dr. Lee E. Titus, 164 W. Napa St., Sonoma Calif. Meets second Monday every other month.

RICHMOND COUNTY RADIOLOGICAL SOCIETY Secretary, Dr. W. F. Hamilton, Jr., University Hospital,

Augusta, Ga. Meets first Thursday of each month at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y. Secretary, Dr. Gerald R. Holzwasser, Rochester General Hospital, Northside Division, 1425 Portland Ave., Rochester 21, N. Y. Meets at 8:15 P.M. on the last Monday of each month, September through May, at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

Secretary, Dr. John H. Freed, 4200 East Ninth Ave., Denver 20, Colo. Annual meeting: Denver Hilton Hotel, Denver, Colo., Aug. 22-24, 1963.

SAN ANTONIO-MILITARY RADIOLOGICAL SOCIETY

Secretary, Dr. Hugo F. Elmendorf, Jr., 730 Medical Arts Bldg., San Antonio 5, Tex. Meets third Wednesday each month in Fort Sam Houston Officer's Club at 6:30

SAN DIEGO RADIOLOGICAL SOCIETY

Secretary, Dr. Charles G. Campbell, 6673 Avenida Manana, La Jolla, Calif. Meets first Wednesday of each month at the University Club.

SAN FRANCISCO RADIOLOGICAL SOCIETY

Secretary, Dr. Walter Coulson, San Francisco General Hospital, San Francisco 8, Calif. Meets quarterly at the San Francisco Medical Society, 250 Masonic Ave., San Francisco 18, Calif.

Section on Radiology, California Medical Association Secretary, Dr. William H. Graham, 630 East Santa Clara St., San Jose, Calif.

SECTION ON RADIOLOGY, CONNECTICUT STATE MEDICAL

SOCIETY Secretary, Dr. Wayne P. Whitcomb, Hospital of St. Raphael, New Haven, Conn. Meetings are held bimonthly.

SECTION ON RADIOLOGY, MEDICAL SOCIETY OF THE DIS-TRICT OF COLUMBIA

Secretary, Dr. Martin A. Thomas, 1150 Connecticut Ave., Washington 6, D. C. Meets at Medical Society Library, third Wednesday of January, March, May and October at 8:00 P.M.

Section on Radiology, Southern Medical Association Secretary, Dr. Robert D. Sloan, University Medical Center, 2500 North State St., Jackson 6, Miss. Annual meeting to be announced.

Section on Radiology, Texas Medical Association Secretary, Dr. Frederick J. Bonte, University of Texas Southwestern Medical School, Dallas 35, Tex. Meets annually with the Texas Medical Association.

SHREVEPORT RADIOLOGICAL CLUB

Secretary, W. R. Harwell, 608 Travis St., Shreveport, La. Meets monthly on third Wednesday at 7:30 P.M., September to May inclusive.

SOCIETY FOR PEDIATRIC RADIOLOGY

Secretary, Dr. John L. Gwinn, Children's Hospital, Los

Angeles 27, Calif. Annual meeting: Queen Elizabeth Hotel, Montreal, Que., Canada, Oct 7, 1963.

Society of Nuclear Medicine

Secretary, Mr. C. Craig Harris, Oak Ridge National Laboratories, Oak Ridge, Tenn. Administrator, Mr. Samuel N. Turiel, 430 N. Michigan Ave., Chicago 11, Ill. Annual meeting: Queen Elizabeth Hotel, Montreal, Que., Canada, June 26-29, 1963.

South BAY RADIOLOGICAL SOCIETY

Secretary, Northern Section: Dr. John S. Wilson, 1515 Trousdale Dr., Burlingame, Calif.; Southern Section: Dr. A. C. Mitchell, 728 Cass, Monterey, Calif. Meets second Wednesday of each month.

South Carolina Radiological Society
Secretary, Dr. George W. Brunson, 1406 Gregg St., Columbia, S. C. Annual meeting (primarily business) in conjunction with the South Carolina Medical Association meeting in May. Annual fall scientific meeting at time and place designated by the president.

SOUTHERN RADIOLOGICAL CONFERENCE

Secretary, Dr. Marshall Eskridge, Mobile Infirmary, P.O. Box 4097, Mobile, Ala. Annual meeting: Grand Hotel, Point Clear, Ala., Jan. 31-Feb. 2, 1964.

SOUTHWESTERN RADIOLOGICAL SOCIETY

Secretary, John M. McGuire, 904 Chelsea, El Paso, Tex. Meets last Monday of each month at 6:30 P.M. in the Paso del Norte Hotel.

TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. B. M. Brady, St. Joseph Hospital, Memphis, Tenn. Meets annually at the time and place of the Tennessee State Medical Association meeting.

TEXAS RADIOLOGICAL SOCIETY

Secretary, Dr. R. P. O'Bannon, 402 Professional Bldg., 1216 Pennsylvania Ave., Fort Worth 4, Tex. Annual meeting: Dallas, Tex., Jan. 31-Feb. 1, 1964.

TRI-STATE RADIOLOGICAL SOCIETY

Secretary, Dr. John H. Marchand, Jr., Methodist Hospital, Henderson, Ky. Meets third Wednesday of Oct., Jan., March and May, 8:00 P.M., Elks Club in Evansville,

University of Michigan Department of Roentgen-OLOGY STAFF MEETING

Meets each Monday evening from September to June, at 7:00 P.M. at University Hospital, Ann Arbor, Mich.

UPPER PENINSULA RADIOLOGICAL SOCIETY

Secretary, Dr. A. Gonty, Menominee, Mich. Meets quarterly.

UTAH STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Richard Y. Card, St. Mark's Hospital, Salt Lake City, Utah. Meets fourth Wednesday in January, March, May, September and November at Holy Cross Hospital.

VERMONT RADIOLOGICAL SOCIETY

Secretary, Dr. John R. Williams, 160 Allen St., Rutland,

VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. Powell G. Dillard, Jr., 715 Church Street, Lynchburg, Va. Meets annually in October. Washington State Radiological Society

Secretary, Dr. Robert H. Rosenberg, 7011 38th Ave., N.E., Seattle 15, Wash. Meets quarterly.

WEST VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. Karl J. Myers, The Myers Clinic-Broad-dus Hospital, Philippi, W. Va. Meets concurrently with Annual Meeting of West Virginia State Medical Society; other meetings arranged by program committee.

WESTCHESTER RADIOLOGICAL SOCIETY

Secretary, Dr. Edward T. Bello, Westchester Academy of Medicine, Section on Radiology, Purchase, N. Y. Meets on third Tuesday of January and October and on two other dates.

Wisconsin Radiological Society

Secretary, Dr. Charles Benkendorf, 408 St. Francis St., Green Bay, Wis. Annual meeting each spring in various places.

CUBA, MEXICO, PUERTO RICO AND CENTRAL AMERICA

Asociación de Radiólogos de Centro America y PANAMÁ. Comprising: Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panamá.
Secretary-General, Dr. Raul Arguello, 5a. Ave., Norte

No. 48, San Salvador, El Salvador. Meets annually in a rotating manner in the six countries.

Sociedad de Radiología de El Salvador Secretary, Dr. Rafael Vaga Gómez.

Sociedad de Radiología de Guatemala Secretary, Dr. Carlos E. Escobar, 92. Calle A 0-05, Zona 1, Guatemala.

Sociedad de Radiología y Fisioterapía Cubana Secretary, Dr. Miguel A. García Plasencia, Hospital Curie, 29 y F, Vedado, Habana, Cuba. Meets monthly at

Curie Hospital. Sociedad Costarricense de Radiologia

Secretary, Dr. James Fernández Carballo, Apartado VIII, San José, Costa <mark>R</mark>ica.

Sociedad Mexicana de Radiología, A. C.

Calle del Oro No. 15, México 7, D. F. Secretary-General, Dr. E. Alvarez Hernández.

Meets first Monday of each month.

Asociación Puertorriqueña de Radiología

Secretary, Dr. R. B. Díaz Bonnet, Suite 504, Professional Bldg., Santurce, Puerto Rico.

Sociedad Radiológica Panameña

Secretary, Dr. L. Arrieta Sánchez, Apartado No. 6323, Panamá, R. de P. Meets monthly in a department of radiology of a local hospital chosen at preceding meeting.

Sociedad Radiológica de Puerto Rico

Secretary, Dr. Jorge Carreras Girard, Suite 504, Professional Bldg., Santurce, Puerto Rico. Meets second Thursday of each month at 8:00 P.M. at the Puerto Rico Medical Association Bldg. in San Juan.

#### British Commonwealth of Nations

Association of Radiologists of the Province of Que-

Secretary, Dr. R. Robillard, Notre-Dame Hospital, 1560 Sherbrooke St., East, Montreal, Que., Canada. Meets four times a year.

BRITISH INSTITUTE OF RADIOLOGY

Honorary Secretary, Dr. R. D. Hoare, 32 Welbeck St., London, W. I, England. Meets monthly from October until May.

Edmonton and District Radiological Society

Secretary, Dr. S. C. Windle, 105 Northgate Bldg., Edmonton, Alberta, Canada. Meets second Monday of each month, October to May.

FACULTY OF RADIOLOGISTS

Honorary Secretary, Dr. C. J. Hodson, 47 Lincoln's Inn Fields, London, W.C.2, England. Annual meeting: St. Bartholomew's Hospital, London, England, June 14–16, 1963.

FACULTY OF RADIOLOGISTS, ROYAL COLLEGE OF SURGEONS IN IRELAND

Registrar, Dr. H. O'Flanagan, F.R.C.P.I., D.P.H., 123 St. Stephens Green, Dublin 2, Ireland.
Section of Radiology of the Royal Society of Medi-

CINE (CONFINED TO MEDICAL MEMBERS)

Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, I Wimpole St., London, W. I, England.

CANADIAN ASSOCIATION OF RADIOLOGISTS

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Montreal Radiological Study Club

Secretary, Dr. Leonard Rosenthall, Montreal General Hospital, Montreal, Que., Canada. Meets first Tuesday evening, October to April.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Société Canadienne-Française d'Electro-Radiologie MÉDICALE

General Secretary, Dr. Maurice Dufresne, 1560 Sherbrooke (East), Montreal, Que., Canada. Meets third Saturday each month.

Toronto Radiological Society

Secretary, Dr. Wallace M. Roy, St. Joseph's Hospitals, 30 The Queensway, Toronto 3, Ont., Canada. Meets second Monday of each month September through May.

College of Radiologists of Australia

Honorary Secretary, Dr. E. A. Booth, c/o British Medical Agency, 135 Macquarie St., Sydney, N.S.W., Australia.

#### South America

Asociación Argentina de Radiología

Secretary, Dr. Lidio G. Mosca, Avda. Gral. Paz 151, Córdoba, Argentina. Meetings held monthly.

Ateneo de Radiologia

Secretary, Dr. Victor A. Añaños, Instituto de Radiologia, Santa Fe 3100, Rosario, Argentina. Meets monthly on second and fourth Fridays at 7:00 P.M. in the Hospital Nacional del Centenario, Santa Fe 1300, Rosario.

Colégio Brasileiro de Radiologia Secretary-General, Dr. Tede Eston de Eston, Caixa Postal 5984, São Paulo, Brazil.

Sociedad Argentina de Radiología, Junta Central, BUENOS AIRES

Secretary, Dr. Edgardo O. Olcese, Santa Fe 1171, Buenos Aires. Meetings are held monthly.

Sociedad Bolivana de Radiología

Secretary, Dr. Javier Prada Méndez, Casilla 1596, La Paz, Bolivia. Meets monthly. General assembly once every two years.

Sociedade Brasileira de Radiologia

Secretary, Dr. Nicola Caminha, Av. Mem. de Sa, Rio de Janeiro, Brazil. General Assembly meets every two years in December.

Sociedade Brasileira de Radioterapia

Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9:00 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

Sociedad Chilena de Radiología Secretary, Dr. J. P. Velasco, Avenida Santa María 0410, Santiago, Chile. Meets fourth Friday of each month.

SOCIEDAD COLOMBIANA DE RADIOLOGIA

Secretary, Dr. Alberto Mejía Diazgranados, Carrera 13, No. 25–31, Apartado aéreo No. 5804, Bogotá, Colombia. Meets last Thursday of each month.

Sociedad Ecuatoriana de Radiología y Fisioterapía Secretary, Dr. Publio Vargas P., Casilla 1242, Guayaquil, Ecuador

Sociedad Paraguaya de Radiología

Secretary, Dr. Miguel González Addone, 15 de Agosto 322, Asunción, Paraguay.

Sociedad Peruana de Radiologia

Secretary, Dr. Luis Pinillos Ganoza, Apartado 2306, Lima, Peru. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta 218, Lima.

Sociedad de Radiologia del Atlantico

Secretary, Dr. Raul Fernandez, Calle 40 #41-110, Baranquilla, Colombia. Society meets monthly at the Instituto de Radiologia.

Sociedad de Radiología, Cancerología y Física

MÉDICA DEL URUGUAY

Secretary-General, Dr. Ernesto H. Cibils, Av. Agraciada 1464, piso 13, Montevideo, Uruguay.

Sociedade de Radiologia de Pernambuco

Secretary, Dr. Manoel Medeiros, Instituto de Radiologia da Faculdade de Medicina da Universidade do Recife,

Caixa Postal 505, Pernambuco, Brazil. Sociedad de Roentgenologia y Medicina Nuclear de LA PROVINCIA DE CÓRDOBA

Secretary-General, Dr. Carlos A. Oulton, Santa Rosa 447, Córdoba, Argentina.

Sociedad Venezolana de Radiología

Secretary-General, Dr. Rubén Merenfeld, Apartado No. 9362 Candelaria, Caracas, Venezuela. Meets monthly third Friday at Colegio Médico del Distrito Federal, Caracas.

#### CONTINENTAL EUROPE

ÖSTERREICHISCHE RÖNTGEN-GESELLSCHAFT

President, Dr. Konrad Weiss, Mariannengasse 10, Vienna Austria. Meets second Tuesday of each month in Allgemeine Poliklinik.

Société Belge de Radiologie

General Secretary, Dr. S. Masy, 256 Chaussée de Wavre, Heverlee-lez-Louvain, Belgium. Meets in February, March, May, June, October, November and December. Société Française d'Electroradiologie Médicale,

and its branches: Socété du Sud-Ouest, du Littoral Méditerranéen, du Centre et du Lyonnais, du Nord, de l'Ouest, de l'Est, et d'Alger et d'Afrique DU NORD. Central Society meets third Monday of each month, except during July, August and September, rue de Seine 12, Paris, France. Secretary-General, Dr. Ch. Proux, 9 rue Daru, Paris 8°,

ČESKOSLOVENSKÁ SPOLEČNOST PRO ROENTGENOLOGII A

Radiologii

Secretary, Dr. Robert Poch, Praha 12, Šrobárova 50, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

DEUTSCHE RÖNTGENGESELLSCHAFT

Secretary, Professor Dr. med. H. Lossen, Universitäts-Röntgeninstitut., Lagenbeckstr. I, Mainz, Germany. Società Italiana di Radiologia Medica e di Medicina

NUCLEARE Dr. Ettore Conte, Ospedale Mauriziano, Secretary,

Torino, Italy. Meets annually. NEDERLANDSE VERENIGING VOOR ELECTROLOGIE EN RÖNT-

GENOLOGIE Secretary, Dr. J. R. von Ronnen, Violenweg 14, den Haag, Netherlands.

SCANDINAVIAN ROENTGEN SOCIETIES

The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Española de Radiología y Electrología Médicas y Medicina Nuclear

Secretary, Dr. D. Aureo Gutierrez Churruca, Esparteros, No. 9, Madrid, Spain. Meets monthly in Madrid.

Schweizerische Gesellschaft für Radiologie und Nuklearmedizin (Société Suisse de Radiologie et DE MÉDECINE NUCLÉAIRE) Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern,

Switzerland.

#### ASIA

Indian Radiological Association

Secretary, Dr. R. F. Sethna, Navsari Building, Hornby Road, Bombay I, India.

Indonesian Radiological Society

Secretary, Professor Sjahriar Rasad, Taman Tjut Mutiah 1, Diakarta, Indonesia.

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#### ROENTGEN DIAGNOSIS

#### HEAD

Spillane, John D. Five boxers. *Brit. M. J.*, Nov. 10, 1962, 2, 1205–1210. (From: United Cardiff Hospitals, and Welsh Regional Hospital Board, Cardiff, Wales.)

An account is given of 5 professional boxers, ranging in age from 33 to 69 years, who were suffering from the so-called "punch drunk" syndrome. All had been retired for a period of 5 to 37 years. Symptoms included ataxia, dysarthria, urinary incontinence, and mental deterioration. Aggressive and violent behavior was the principal abnormality in 1. Physical findings ranged from the absence of positive findings in I to an extensor plantar response, limb weakness, slurring of speech and unsteadiness of gait in 2 others. Except for calcification in the internal carotid arteries and falx cerebri in the oldest patient's skull roentgenogram, there were no positive findings on plain roentgenograms. Pneumoencephalograms revealed absence of the septum pellucidum in I patient, cavum septi pellucidi in 2 with the septum appearing perforated in 1 of them, and evidence of cerebral atrophy in the other 2.

The role of repeated trauma in the production of these brain changes is not determined. Abnormalities of the septum pellucidum may possibly be an acquired, post traumatic lesion associated with the brain disorder in the "punch drunk" syndrome. A plea is made for clinical study of these men and pathologic examination whenever possible.—David Morse, M.D.

Hamby, Robert I., and Desposito, Franklin. Congenital intradural arteriovenous fistula and congestive heart failure in infancy. J. Pediat., Oct., 1962, 61, 590–594. (From: The Department of Pediatrics, Long Island Jewish Hospital, New Hyde Park, L. I., N. Y.)

The authors present an interesting case of a female infant first hospitalized at 6 weeks of age because of acute respiratory distress. The patient was thought to be in congestive failure because of congenital heart disease; she was treated with digoxin and diuretics and 3 weeks later discharged from the hospital.

Five days after discharge, the infant was admitted to the Long Island Jewish Hospital because of a persistent cough. The patient's condition changed and after 3 weeks in the hospital a systolic bruit was felt in the upper posterior neck and mastoid region bilaterally.

An angiocardiogram, which was obtained through a femoral vein, showed a dilated right atrium and an unusual distribution of opaque medium in the posterior cranial fossa suggestive of a venous angioma. The child remained in poor condition and died at 14 weeks of age.

Postmortem study revealed edema fluid in the alveoli, moderate enlargement of the left ventricle and dilatation of the right atrium and ventricle. Examination of the brain disclosed compression of the cerebellum with the brain stem embedded in its surface. There was a malformation of the vascular system involving the tentorium, dura of the posterior fossa and the caudal third of the adjacent falx cerebri.

Numerous vascular channels were seen through the inner and outer surfaces of the dura. The major venous sinuses emptied into these vascular spaces. The dura was markedly thickened, especially the tentorium, being 5 cm. in thickness.

A discussion of intracranial arteriovenous malformations follows, with reference to the diagnostic features and association with congestive heart failure in the infant.—Thomas P. McNeill, M.D.

Sutton, David, and Trickey, S. E. Subarachnoid haemorrhage and total cerebral angiography. *Clin. Radiol.*, Oct., 1962, 13, 297–303. (From: Maida Vale Hospital [The National Hospitals for Nervous Diseases], London, and St. Mary's Hospital, London, W.2, England.)

While bilateral carotid arteriography alone will demonstrate the site of subarachnoid hemorrhage in the majority of instances, there are many cases where such a study fails to reveal any abnormality. The object of this article is to discuss the value of arteriography, with special reference to vertebral arteriography in the diagnosis of subarachnoid hemorrhage. In practice, injection of a single vertebral artery fails to show an important segment of the intracranial circulation, that is, the terminal segment of the contralateral vertebral artery with its posterior inferior cerebellar branch. Occasionally the termination of both vertebrals can be shown by injection of one vertebral artery because of reflux down the contralateral vertebral artery.

The commonest cause of spontaneous subarachnoid hemorrhage is a ruptured aneurysm. Lesions less frequently found are angiomas, hematomas, and tumors. The common sites for bleeding aneurysms shown by vertebral angiography are: (1) the bifurcation of the basilar artery; (2) the junction of the posterior cerebral and posterior communicating arteries; and (3) the origin of the posterior inferior cerebellar artery from the vertebral artery.

In the authors' series of 557 cases, after carotid injection only, lesions were demonstrated in 421 cases or about 75 per cent. For various reasons 59 of the 136 negative cases were not examined further. Seventy-seven of the 136 negative cases were investigated additionally by vertebral arteriography, 29 had positive findings on unilateral vertebral arteri-

ography. Of the remaining 48 negative cases, 25 were examined further by contralateral vertebral arteriography; and, of these, 7 were shown to have lesions causing subarachnoid hemorrhage.—Samuel G. Henderson, M.D.

STEIN, BENNETT M., McCORMICK, WILLIAM F., RODRIGUEZ, JESUS N., and TAVERAS, JUAN M. Postmortem angiography of cerebral vascular system. A.M.A. Arch. Neurol., Dec., 1962, 7, 545–559. (Address: Dr. B. M. Stein, Columbia-Presbyterian Medical Center, 622 West 168th Street, New York 32, N. Y.)

One hundred and thirty postmortem examinations of the cerebral blood supply in individuals, for the most part over 50 years of age, were carried out. The roentgenographic technique enabled the authors to visualize the entire vascular tree concerned with cerebral blood supply from the aortic arch to the circle of Willis. Subsequently in every case, the aortic arch with its branches, the vertebral artery to its intra-osseous portion, and the carotid siphon, including the intracavernous portions, were removed bilaterally. These vessels were then cross-sectioned after special fixation. In an evaluation of the extracranial vessels, 50 per cent stenosis as measured from the roentgenograms was arbitrarily chosen as the dividing line between significant and nonsignificant atheromatous involvement of a vessel. The brains were removed and the intracranial vessels were likewise studied.

Thirty-six cases, 28 per cent of the total postmortem examinations, had 50 per cent or more stenosis of the extra- and/or intracranial vessels. Of this group only 9 showed clinical evidence of neurologic disease. There was a 22 per cent incidence of significant atheromatous involvement in the 121 asymptomatic individuals.

In an appraisal of the 36 cases with occlusive disease, comparing a group of 14 cases with cerebral infarction and 22 without, a higher degree and diffuseness of atheroma in the extracranial vessels in the former group was noted. One must be cautious in accepting an angiographic demonstration of a single extracranial lesion as the direct or sole cause of a patient's neurologic symptoms.

It is pointed out that the disease has a peculiar predilection for certain areas of the extracranial vasculature, namely, carotid sinus, vertebral-subclavian junction, the carotid siphon, and the origin of the great vessels from the aortic arch. The eccentricity of the atheromatous lesions necessitates multiple views of the suspected area. It would appear that the factors of tortuosity are not related to atheroma and that lesions in the intra-osseous canal of the vertebral artery were insignificant. Severe disease can exist in a significant population without producing symptoms.—William C. MacCarty, 7r., M.D.

#### NECK AND CHEST

Kossel, A. Interstitial plasma-cell pneumonia in children receiving long-term corticosteroid treatment. *German Med. Month.*, Oct., 1962, 7, 325–328. (From: The Department of Paediatrics, University of Tübingen, Germany.)

Interstitial plasma-cell pneumonia due to Pneumocystis Carinii used to be regarded as a disease confined to infants, with a maximum incidence at 8 to 12 weeks, but in recent years a number of cases in older children and adults have been reported. Most of the adults had been under treatment with roentgen rays, cytostatic drugs or glucocorticoids for some grave disease of the lymphatic or hemopoietic systems; and the suspicion has been voiced that steroids, in connection with the underlying disease and other therapeutic measures, carry a risk of interstitial plasmacell pneumonia. A few cases have been reported in adults and older children not receiving steroids, but these cases have all had predisposing factors such as agammaglobulinemia, chronic or recurrent infections, or wasting diseases. Others had been treated with roentgen rays, radiogold or cytostatic agents.

Thirteen case reports are given, with ages from 9 months to 12 years. Only 4 of the 13 children survived. This form of pneumonia is clinically, serologically and pathologically identical with the disease in infants. It does not develop until steroids have been given for a certain length of time, the average interval being 60 to 70 days (range 50 to 90 days). The onset of this pneumonia does not coincide with the highest level of steroid dosage, when resistance to infection might be expected to be at its lowest ebb. It appears only after steroids have been given for a considerable time. It is also noted that almost all the patients in this series had been in contact with "influenzal" infections within 3 weeks before the onset of the pneumonia, and some had developed transitory illnesses of this kind. One point of special interest was the observation of several chains of infection, each of them ending in a case of interstitial plasma-cell pneumonia. The onset was similar in all the children in the chain, but only in those receiving steroids did interstitial plasma-cell pneumonia ensue. It is noted that all the predisposing factors have one common feature; namely, their effect on the lymphatic system.

It is clear that steroid therapy entails a risk of interstitial plasma-cell pneumonia, and it is obvious that the indications for this form of treatment must be even more carefully scrutinized than before. When its use is unavoidable, the course of treatment should not exceed 2 months and care should be taken to protect children from any source of infection, however slight.—Douglas S. Kellogg, M.D.

Sieniewicz, D. James, Martin, John R., Moore, Sean, and Miller, Alec. Rheumatoid nodules in the lung. J. Canad. A. Radiologists, Sept., 1962, 13, 73-80. (From: The Montreal General Hospital, Montreal, Quebec, Canada.)

A variety of nonspecific pulmonary lesions and pleural changes have been demonstrated in patients who have had rheumatoid arthritis. Many instances of pleural effusions in association with exacerbations of joint manifestations have been reported, and also diffuse reticulation throughout the lungs and lesions of a nodular nature. Many have definite pulmonary symptoms which subside when the joint symptoms disappear. The pulmonary nodules are peripheral in location, usually subpleural in the lung bases or apices, and there is frequently associated pleural reaction over the lesion. Microscopically, the nodules have shown the distinctive histologic pattern resembling the subcutaneous rheumatoid nodule.

Two cases of nodular pulmonary lesions with overlying pleural reaction are reported. In 1 case there was cavitation within a nodule which had ruptured, releasing its contents into the pleural cavity.

The lung lesions described are not specific histologically for any one condition. They have been seen in a wide variety of tissue reactions to agents such as dust, fungi, or *Mycobacterium tuberculosis*.

Similarly, the roentgenographic appearance of the lung in rheumatoid disease is not specific. Diffuse interstitial fibrosis may be due to a large variety of conditions including all the collagen diseases. The nodular lesions have only been seen in obvious rheumatoid arthritis. Similar nodular lesions were reported by Caplan in a review of Welsh coal miners examined for pneumonoconiosis with the complication of progressive massive fibrosis. In some of his cases with nodular lesions, the pulmonary process preceded the arthritic process by several years. Caplan was unaware that nodules could occur without pneumonoconiosis.—Lois Cowan Collins, M.D.

Fišer, F. Bronchiale Verzweigung mit besonderer Berücksichtigung der Lungensubsegmente. (Bronchial branching with particular consideration of the subsegments of the lungs.) Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin, Oct., 1962, 97, 425–433. (Address: Tuberkuloseklinik des Institutes für die Ärztliche Fortbildung, Prag 8, Bulovka, CSSR.)

The material consists of 528 bronchograms made between 1957 and 1960. Cases with lobar shrinkage and other causes of bronchial displacement were deleted. The study concerns the remaining right-sided bronchograms of 98 patients and left-sided bronchograms of 96 patients. In 20 of these only the right upper lobe, in 10 only the left upper lobe, and in 2 only the left lower lobe had been filled. The segmental bronchi were evaluated on the basis of the

universally adopted classification combined from the publications of E. A. Boyden, and of G. J. Cordier and C. Cabrol. The incidence of atypical branching was not sufficient to invalidate the classification.

In 1953, at the International Oto-Rhino-Laryngological Convention in Amsterdam, Chevalier Jackson asked that a universally accepted classification of subsegmental bronchi be prepared; but this suggestion was rejected. The author believes that such a classification would be quite useful and should be worked out.—E. R. N. Grigg, M.D.

Huzly, A. Das Mittellappensyndrom. (The middle lobe syndrome.) Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin, Oct., 1962, 97, 407–424. (Address: Chefarzt der Chirurg. Abt., Sanatorium Schillerhöhe, Gerlingen über Stuttgart, Germany.)

The term middle lobe syndrome was coined by Graham, Burford, and Mayer in 1948. Its meaning was subsequently distorted to include various etiologies, such as tuberculosis, intrabronchial foreign bodies, neoplasms, etc. Then some authors rejected the term middle lobe syndrome as too ambiguous. The author wishes to retain the meaning which Graham and his co-workers had originally intended for the middle lobe syndrome, *i.e.*, bronchiectatic and other irreversible parenchymatous changes occurring distal to inflammatory stenosis (etiology unspecified) of the middle lobe bronchus.

Middle lobe atelectasis (which is not the same thing as shrinkage) can be distinguished from consolidation by the contour of the lobe, especially on lateral roentgenograms. A space-diminishing process produces concave outlines; an infiltration makes them convex. When a portion of the contour is concave and another convex, it indicates that an infiltration has developed in an atelectatic lobe.

Huzly has performed over 10,000 bronchoscopies and over 6,000 bronchographies, which resulted in the identification of the middle lobe syndrome in 48 patients. Twenty of these 48 were tuberculous; in 21 the etiology was unknown. Ten illustrative case histories included in the paper emphasize the fact that the middle lobe syndrome appears also in the older age groups, and may develop in as short a time as a few weeks after a bout of influenza. Resection is curative, but often technically difficult because of adhesions, to the point where the lower lobe must be ablated simply due to its being "stuck" to the middle lobe.—E. R. N. Grigg, M.D.

Aronovitch, M., and Szabo, A. J. Prolonged retention of a radiolucent bronchial foreign body. *Canad. M. A. J.*, Nov. 17, 1962, 87, 1071–1073. (From: The Chest Service, Queen Mary Veterans Hospital, Montreal, Quebec, Canada.)

The recognition of nonopaque, relatively inert foreign bodies causing long standing bronchial obstruction is difficult. This disorder tends to simulate other disease processes and frequently there is a prolonged asymptomatic period between the time of aspiration and the patient's seeking medical aid.

A case of an aspirated, radiolucent dental plate fragment which has been lodged in a bronchus for 10 years is reported. The patient, a 49 year old seaman, presented with a large anteriorly convex mass projecting from the right posterior chest wall. A laminagram demonstrated complete obstruction of the right lower lobe bronchus. A bronchoscopic diagnosis of bronchogenic carcinoma was made, but the biopsy tissue diagnosis was nonspecific granulation tissue. During a second bronchoscopy, a whitish stony-hard mass was revealed in the underlying tissue. Only then did the patient remember that approximately 10 years before admission he was involved in a fight during which his artificial denture broke and all the pieces were not recovered. He had a few coughing spells following the fight but these soon quieted down, and he remained asymptomatic until the present illness.

Thoracotomy revealed an empyema sac and a large purulent abscess in the right lower lobe with surrounding areas of atelectasis. A foreign body was removed from the orifice of the right lower lobe bronchus and was identified as a broken part of an artificial denture consisting of 3 teeth. The post-operative course was uneventful.—Francis P. Shea, M.D.

Dollery, C. T., Hugh-Jones, P., and Matthews, C. M. E. Use of radioactive xenon for studies of regional lung function: a comparison with oxygen-15. *Brit. M. J.*, Oct. 20, 1962, 2, 1006–1016. (From: The Department of Medicine, Postgraduate Medical School, and the Medical Research Council Radiotherapeutic Research Unit, Hammersmith Hospital, London, England.)

In lung disease and in heart disease there may be marked changes in the distribution of gas and blood in the lungs. These changes can be of diagnostic importance and can cause widespread change in bodily function. The use of radioactive gases has made the study of regional lung function much easier. Radioactive xenon was the first gas to be used, but initially it was used only to give approximate measurements of local ventilation and so was of limited value. In more recent years radioactive oxygen has been employed. This isotope, used as such or in the form of carbon dioxide, has proved of great value in studying lung physiology and also in studying the regional changes in lung function which occur both in lung disease and in heart disease, as for instance in mitral stenosis and congenital heart disease.

The main disadvantage of O<sup>15</sup> (radioactive oxygen) is its very short half-life of 2 minutes, which means that patients have to be investigated in a room adjacent to the cyclotron. Since Xe<sup>133</sup> is produced in a nuclear pile and has a half-life of 5 days, it is generally available unlike O<sup>15</sup>. Xenon was found to be of particular value in studying patients who had poorly ventilated regions in their lungs and to be a substitute for O<sup>15</sup> for most clinical purposes, but found not to be as versatile as O<sup>15</sup> for some research requirements.

Measurements made in 4 young normal adults showed that an upright normal man has a relatively low flow through the upper zones of the lungs. Studies in heart disease show that in mitral stenosis (severe cases) the blood flow may be much greater in the upper zone of the lung than in the lower zone. Radioactive oxygen-labelled carbon dioxide has been of particular value in the detection of left-to-right cardiac shunts. This isotope is very diffusible and soluble, so it passes rapidly into the pulmonary capillary blood and some of the radioactive blood soon returns to the counting field through the shunt. In a patient with a large lung bulla, injected Xe<sup>133</sup> showed that there was virtually no blood flow through the bullous area.

Xenon proved of particular value in studies of poorly ventilated regions of the lungs but was useless for detecting left-to-right shunts. For most other purposes the two methods gave similar results. The main practical advantage of xenon lies in its longer half-life (5.4 days) against the very short one (2 minutes) of oxygen. Several charts, reproductions of roentgenograms, and spirometer tracings are included.—Douglas S. Kellogg, M.D.

Ormond, Robert S., and Eyler, William R. Roentgen diagnosis of cardiac competence. *Radiology*, Sept., 1962, 79, 378–383. (From: The Henry Ford Hospital, Detroit 2, Mich.)

The appearance of the chest on a roentgenogram usually correlates well with the physiologic state of the patient, and when there is disagreement between the clinical and roentgenologic evaluation there is a need for amplifying studies. The roentgen factors to be considered are cardiac size and configuration, pulmonary venous and arterial appearance, and the presence of failure as manifested by interstitial and free fluid. Accurate localization of the cardiac abnormality is mandatory for meaningful evaluation of the pathologic status.

The pulmonary veins are an accurate gauge of the pressure within the left atrium when it is low or moderately elevated. Left atrial pressures below 16 mm. of mercury produce distention of both upper and lower lobe veins proportional to the pressure. Above 16 mm. of mercury the upper lobe veins continue to enlarge. The behavior of the lower lobe veins has been inconstant in the authors' experience. Pulmo-

nary arterial hypertension is accompanied by alterations in the size and configuration of the arterial shadows in the lung fields. Constriction of the peripheral arteries with rapid tapering of the secondary and tertiary arteries has been described. There is often an accompanying enlargement of the central arterial trunks, producing disparity between the peripheral and central lung fields. The main pulmonary artery is also enlarged, and this is usually recognized more easily and earlier than the peripheral changes. The length of time a physiologic change has been present will also influence the findings in the lung fields.

Fluid begins to accumulate in the interstitial spaces with the failure of the myocardium. When extreme, it is seen as frank pleural effusion. When less marked, it is recognized as basal lymphatic distention and a general haziness of the lung fields. These findings are present with elevated arterial and venous pressures; but the relationship between pressure and fluid is not constant, suggesting that other factors are present. Inconstantly seen with visible lymphatics is the presence of a stripe of water density along the lateral chest margin, possibly representing subpleural fluid rather than free effusion. Cardiac enlargement may be the most impressive finding, particularly with aortic stenosis. A mitral valvular lesion may also produce marked cardiac enlargement with little evidence of pulmonary hypertension. Such patients may succumb to their disease without producing signs of chronic pulmonary arterial and venous hypertension. Obviously such patients should not be dismissed because of the lack of evidence of altered pulmonary physiology.—James C. Moore, M.D.

Lehman, J. Stauffer, Boyle, James J., Jr., and Debbas, Joseph N. Quantitation of aortic valvular insufficiency by catheter thoracic aortography. *Radiology*, Sept., 1962, 79, 361–370. (From: The Department of Radiology of the Hahnemann Medical College and Hospital of Philadelphia, Philadelphia, Pa.)

The advent of surgical methods for treatment of rheumatic aortic valvular lesions has increased the importance of roentgenologic study of the valve, determination of the extent and character of its pathologic changes, and the degree of its functional impairment. The procedure of catheter thoracic aortography, introduced by Radner in 1948, is the most satisfactory method for study.

A series of 273 cases is presented, with a description of the technique employed. In 140 patients, the purpose of the examination was evaluation of any aortic insufficiency. Of these, 129 showed varying degrees of aortic valvular incompetence with left ventricular reflux, a finding which agreed with the clinical diagnosis. The authors are convinced that a competent aortic valve will not allow significant re-

flux of contrast material into the left ventricle. Therefore, they feel that a significant reflux into the left ventricle, occurring throughout the aortic injection and through several cardiac cycles, is fairly conclusive evidence of a degree of incompetence of the aortic valve. The authors judge the degree of regurgitation from I plus to 4 plus on the basis of the rapidity of reflux into the left ventricle and the degree of opacification of the left ventricular chamber.

Of the total 273 cases in which examination was attempted, 133 had no clinical evidence of aortic insufficiency; and in none of the 129 successful examinations in this group was appreciable left ventricular reflux observed, thus supporting their conclusions.

Besides quantitation of aortic insufficiency, the procedure has been used for coronary artery visualization, evaluation of congenital heart disease, mitral valvular disease, aortic stenosis, aortic aneurysm and, in one case each, of mediastinal mass and pulseless disease.—Ralph F. Bowman, M.D.

KAVANAGH-GRAY, DORIS. Spontaneous closure of a ventricular septal defect. *Canad. M. A. J.*, Oct., 1962, 87, 868–870. (From: The Clinical Investigation Unit, St. Paul's Hospital, Vancouver, British Columbia, Canada.)

The patient in the case reported was first seen when she was 3 weeks old because of a murmur which had been present since the fifth day of her life. She weighed 7 pounds, 12 ounces and was asymptomatic.

The physical examination was entirely normal except for a harsh Grade IV pansystolic murmur along the left costal border. The greatest intensity of the murmur was at the fourth anterior interspace. The second pulmonary sound was of normal intensity but narrowly split. Electrocardiogram and chest roentgenograms were normal. Cardiac catheterization showed a definite left to right shunt at the ventricular level (see Table I). Angiocardiogram showed

Table I
CARDIAC CATHETERIZATION DATA

Age	Pressure (mm.Hg)			Oxygen saturation (per cent)			
	RV	PA	SVC	RA	RV	PA	
3 weeks 7 months				68 68	68.5 68	73·5 68	77 68

SVC, superior vena cava; RA, right atrium; RV, right ventricle; PA, pulmonary artery.

reopacification of the right ventricle from the left. At the age of 7 months all examinations were normal including catheterization and selective angio-cardiography (Table 1). The ventricular defect apparently had closed. There was no evidence of pulmonary hypertension or pulmonary stenosis which

might equalize the pressures of the right and left ventricles.—Frank M. Windrow, M.D.

Dölle, W., Martini, G. A., and Petersen, F. Idiopathic familial cardiomegaly with intermittent loss of protein into the gastro-intestinal tract. *German Med. Month.*, Sept., 1962, 7, 300–306. (From: The First Medical Division, University of Hamburg, Hamburg-Eppendorf and the X-Ray Department of the General Hospital, Hamburg-St. Georg, Germany.)

This disease is characterized by cardiac enlargement and signs of cardiac failure occurring without reasonable explanation in several members of a family. Hypoproteinemia is a constant finding, along with loss of proteins into the gastrointestinal tract.

The 2 cases presented are sisters, 33 and 37 years of age.

The disease became evident at the ages of 28 years and 33 years, and the early symptoms were dyspnea on exertion, edema and lassitude. The heart and liver became enlarged and ascites developed in each patient. The cardiac configuration did not fit any valvular lesion. Electrocardiogram showed only nonspecific ST-T wave changes and right axis deviation. There was increased venous pressure, and a soft murmur with a split second sound on auscultation.

The pathologic findings usually are cardiac muscular hypertrophy, occasionally necrosis and vacuolization of the muscle fibers, and increased fibrosis.

The therapy used in the 2 cases was digitalis, low sodium diet and diuretics. Prednisone, 15 to 30 mg. daily, increased the appetite and reduced the cachexia. Mitral valvular disease was suspected at first in both patients but was disproven.

The diagnosis depends on: finding no other cause for the cardiomegaly, involvement of 2 or more members of a family and biopsy of a cardiac muscle. The definitive diagnosis can be made only at autopsy.—
Frank M. Windrow, M.D.

STOLBERG, HAROLD O., and HOLMES, R. BRIAN. Constrictive epicarditis and hemopericardium. J. Canad. A. Radiologists, Sept., 1962, 13, 86–94. (From: Toronto General Hospital, Toronto, Ontario, Canada.)

Angiocardiography offers a method of diagnosing pericardial effusion, either generalized or localized, and constrictive pericarditis, and of differentiating between the two conditions. It should be recommended in all cases in which the possibility of pericardial disease exists.

Pericardial fluid accumulation is prevented posteriorly by fixation of the heart to the posterior mediastinum by the 4 pulmonary veins, and the pericardial reflections between them, and the 2 venae cavae. Expansion of the pericardial sac is limited inferiorly on the right by the phrenopericardial ligament, and ventrally by the superior sternopericardial ligament attached to the manubrium and the inferior sternopericardial ligament attached to the xiphoid process. Pericardial effusion surrounds the heart anteriorly, inferiorly and laterally. The roots of the superior vena cava, the pulmonary artery and aorta are enclosed by epicardium for a distance of approximately I inch. Because of the fixation of the pericardium, fluid accumulation results in displacement of the heart within the pericardial sac. Angiocardiographic manifestations are best recognized during the dextrocardiogram phase. In the anteroposterior projection, fluid accumulation is best demonstrated covering the main pulmonary artery segment. Larger accumulations laterally widen the shadow of the right atrial wall (normal 1-4 mm.), and the inner and outer borders of the wall diverge. The thickness of the wall of the superior vena cava is increased. The normal convexity of the right atrial cavity is a straight or convex margin in the presence of fluid accumulation. Limitation of diastolic expansion of the right atrium may be apparent on serial roentgenograms, and would probably be particularly striking by cineroentgenographic examination.

In the lateral view, the accumulation of fluid is seen anteriorly, obliterating the retrosternal air space and displacing the main pulmonary artery and right ventricle posteriorly.

The indirect signs are similar for both fluid accumulations and pericardial constriction and include dilatation of both venae cavae and an increased tendency of contrast material to reflux into the inferior vena cava. With either cardiac tamponade or constrictive pericarditis, the circulation time is prolonged and clearance of contrast material from the superior vena cava is delayed. There may be right ventricular enlargement and pulmonary venous congestion.

The levocardiogram phase demonstrates the absence of fluid accumulation behind the heart. Fluid present within the lateral pericardial pouches projects over the region of the aortic arch and the origins of the pulmonary vein.

In constrictive pericarditis, the widening of the soft tissue along the right atrium is said not to exceed 8 mm. The most significant diagnostic feature consists of an irregular deformity of the right atrial wall associated with localized fixation, best appreciated by serial roentgenograms or particularly by cineangiography, which also demonstrates the limitation of diastolic filling. The lateral projection is of limited value in constricting lesions. Posterior displacement of the pulmonary artery and right ventricle is not observed in this condition.

The cases presented revealed the clinical pathologic features of a syndrome which consists of delayed pericardial, pleural and pulmonary reaction. The clinical entities associated with this syndrome are as follows: (1) recurrent idiopathic pericarditis; (2)

postpericardiotomy syndrome (postcommisurotomy syndrome with cardiac surgery); (3) postpericardiotomy syndrome with traumatic pericarditis; (4) postmyocardial infarction syndrome; and (5) postradiation pericarditis with hemorrhage.—Lois Cowan Collins, M.D.

GRAVIER, J., SCHLIENGER, R., VERNEY, R. N., and DALLOZ, CL. Deux cent cinquante ponctions ventriculaires gauches sans accident. (Two hundred and fifty left ventricular punctures without accident.) J. de radiol., d'électrol. et de méd. nucléaire, Oct., 1962, 43, 569-574. (From: Clinique cardio-vasculaire de la Faculté de Médecine de Lyon, and Service de Chirurgie thoracique et cardiaque de l'Hôpital E.-Herriot, Lyon, France.)

In performing left ventricular punctures for the purpose of angiography, the authors prefer the intercostal to the sub-xiphoid route. The needle's caliber is 1.4 mm. for adults (1.0 mm. for infants); its end is closed and there are lateral openings. It is inserted at the cardiac apex and parallel to the cardiac axis; placement is confirmed roentgenographically as well as by the evaluation of pressures; 20 minutes usually suffices for the entire procedure.

No deaths or severe complications resulted although 40 incidents were recorded in the 250 procedures, these being: failure of the procedure (4), errors in placement of the needle (20), probable trauma to a coronary branch (1), pericardial bleeding (4), partial pneumothorax (4), shock (1), and reaction to codeine (4).

The authors feel that left ventricular puncture followed by angiography is a sure and rapid procedure which gives interesting information in mitral and aortic diseases and certain congenital cardiopathies.—Frank A. Riebel, M.D.

#### ABDOMEN

SIMLER, M., WEILL, J. P., KEMPF, F., and WAHL, R. Confrontations radiogastroscopiques à propos de 130 cas dont 72 gastrites. Gastrite endoscopique et gastrite radiologique. (Radiologic and gastroscopic comparison of 130 cases of which 72 had gastritis. Endoscopic gastritis and radiologic gastritis.) J. de radiol., d'électrol. et de méd. nucléaire, Aug.—Sept., 1962, 43, 485–488. (From: Clinique Médicale A, Section de Gastro-Entérologie, Strasbourg, France.)

This work attempts to assess the relative value of gastroscopy and the roentgen examination of the stomach. Roentgenograms were normal in 25 of 72 cases of gastritis so that gastroscopy was quite essential for the diagnosis of these patients. In the case of gastric ulcer and carcinoma it was believed that the

number of cases in the study was too low for valuable conclusions. However, it is stated that in such diseases the diagnosis is above all a roentgenologic one and gastroscopy is only a complementary investigation, sometimes very useful.

Among the 130 patients of the present study, it is stated that gastroscopy was essential for the discovery of 30 per cent of the lesions. This included 25 with gastritis, 2 with ulcers, 1 with carcinoma, and 11 with various lesions in stomachs previously operated upon.—Charles M. Nice, Jr., M.D.

KARON, ALLAN B. The delayed gastric syndrome with pyloric stenosis and achlorhydria following the ingestion of acid: a definite clinical entity. Am. J. Digest. Dis., Nov., 1962, 7, 1041–1046. (Address: 6236½ W. Manchester Boulevard, Los Angeles 45, Calif.)

Two patients who did not succumb immediately to acid ingestion and in whom typical delayed sequelae were seen are reported. These sequelae are: (I) following I to 2 weeks of conservative therapy, the patient is usually able to leave the hospital with minimal symptoms; (2) in about 2 to 6 weeks after ingesting the acid, the patient is found to have a tight pyloric or antropyloric stenosis; (3) the esophagus is usually uninvolved at the time the pyloric stenosis is present; (4) in reported cases in which analysis for free HCl was made, achlorhydria after histamine was found.

Surgical intervention to bypass the pyloric obstruction is necessary for survival of these patients. The gross and microscopic pathologic changes seen in the involved portion of the stomach, muscular hypertrophy and fibrosis, produce a rigid wall similar to that of scirrhous carcinoma.

The possibility of mistaking the rigid pyloric or antropyloric stenosis for carcinoma, particularly in view of the associated achlorhydria, is mentioned.— William C. MacCarty, Jr., M.D.

Fontaine, René, Warter, Pierre, and Weill, Francis. Étude radiologique de sept cancers developpés sur des moignons de gastrectomie pour ulcère. (Radiologic study of seven cancers in the stumps of gastrectomy for ulcer.) J. de radiol., d'électrol. et de méd. nucléaire, Aug.—Sept., 1962, 43, 465—469. (From: Clinique Chirurgicale A, Strasbourg, France.)

Malignancies were found in gastric stumps in 7 patients, which represents about 30 per cent of the frequency of jejunal ulcers occurring about the anastomosis following partial gastrectomy for ulcer. In the present series 5 patients had previously been subjected to gastrectomy for an ulcer of the lesser curvature of the stomach and 2 for duodenal ulcer.

The pathogenesis and etiology of carcinoma in these cases is not entirely clear, but may be related to the lack of acid, chronic inflammation, and atrophic mucosa.

The symptoms included dysphagia in 2 patients, epigastric pains simulating peptic ulcer in 3 patients, and alteration of the general condition in 2 patients.

Roentgenologic signs of carcinoma included rigidity due to infiltration and formation of a mass which protruded into the lumen in some cases.—*Charles M. Nice*, Jr., M.D.

BÉRAUD, CL., DEFRENNE, P., BRESSIEUX, R., and GUILLEMINET, M. Les aspects radiologiques de l'appendicite aiguë chez l'enfant. (Radiological aspects of acute appendicitis in children.) J. de radiol., d'électrol. et de méd. nucléaire, June–July, 1962, 43, 374–382. (From: Clinique de Chirurgie Infantile and Service de Radiologie de l'Hôpital Debrousse, Chemin Saint-Irénée 29, Lyon, France.)

It is generally accepted that acute appendicitis does not require a roentgenologic examination and that the surgeon relies mainly on clinical signs. In children, however, and particularly in babies, appendicitis may sometimes present particularly misleading characteristics. This is the most frequent affection encountered in pediatric surgery and it causes fatalities which could be avoided. Among 38 cases of appendicitis in children less than 3 years old, Fields reports 31 perforations with 13.2 per cent fatalities, and Longino admits 75 per cent with perforations before the age of 4 and deplores a mortality of 50 per cent before the age of 2.

Pediatricians and surgeons recognize the necessity of an early diagnosis which is made more difficult by the infancy of the patients and the increased severity of the disease. History taking does not exist at that age, and the examination is often laborious. The abdominal palpation may be misleading, the fever is inconstant or paradoxically low, and the bowel function may be maintained. High leukocytosis, especially in polymorphonuclear cells, is a reliable sign, but it is absent in the early stages; hence, the value of distinctive roentgenologic signs may be considerable.

The authors present recent statistics covering 10 months and 364 cases of appendicitis, of which 107 were serious: 46 acute, 23 purulent, 13 abscessed, and 23 with perforation and peritonitis.

Roentgenologic examination is often performed in cases of suspected appendicitis, not to confirm but to exclude this diagnosis, where the surgeon fears either an occlusion or a renal or ureteral lithiasis. The examination consists of flat anteroposterior roentgenograms in dorsal decubitus and in standing position. Sometimes other positions are useful, namely anteroposterior roentgenograms in lateral decubitus with the horizontal beam.

In the inflammatory area, a paralytic ileus is cre-

ated, localized at first, then extending proximally to produce pseudo-occlusive signs. Distally, the colon reacts by a more or less violent evacuation, and this explains the roentgenologic signs.

- I. Acute Appendicitis. One may frequently observe a gas shadow in the cecum with a liquid level on the erect roentgenogram. A smaller liquid level may be seen in the terminal ileum. In the left lower quadrant some small bowel loops may be seen dilated, rarely distended. The intervening space is dense, due to fluid filled loops. On the recumbent roentgenogram, fluid and gas are spread throughout; and the loops with their thickened walls form a rosette pattern around the right iliac fossa. The internal border of the cecum is often irregular and loses its polycyclic contours. Antalgic lumbar scoliosis may be noted as an accessory sign on the standing roentgenogram. Blurring of the psoas muscle shadow is seen in older children.
- 2. Appendicular Abscess. This appears as a dense shadow with round contours which occupies the iliac fossa, the right flank or the pelvis, and even the subhepatic area. This complication indicates a perforation or a suppuration from the appendicular wall. Sometimes a pyogaseous abscess may be recognized when a fluid level appears with a semicircular air collection above. An excellent associated sign is the disappearance of the preperitoneal line on the side involved.
- 3. Appendicular Peritonitis. This is most frequently encountered in young children. The appendicitis presents a picture of primary peritonitis, especially in the newborn, where the abscess is uncommon. It often occurs during the first 20 days of life from maternal septicemia or an infected circumcision. The roentgenologic signs of these neonatal forms are caused by edema blurring the planes of the abdominal wall and giving a spongy appearance to the fat layer. Physiologic aerocoly accompanies the paralytic ileus and the most important sign is the enlarging of adjacent loops by fluid. Perforation is the predominant cause, and appendicoliths may play an important role because their calcification facilitates detection. Excellent roentgenograms are a prerequisite in order to detect the extra-intestinal bullae, which are best shown on lateral roentgenograms with the horizontal beam.

In conclusion, appendicitis may produce specific signs, or signs indicative of a definite inflammatory reaction in the right lower quadrant, with disturbance of the bowel function in older children, or peritoneal involvement in the newborn. In all cases, flat roentgenograms are useful; but in the case of the newborn, they are indispensable.—H. P. Lévesque, M.D.

BOLEY, SCOTT J., SCHWARTZ, SOLOMON, LASH, JAMES, and STERNHILL, VERNON. Reversible vascular occlusion of the colon. Surg., Gynec. & Obst., Jan., 1963, 1, 53–60. (From: Departments of Surgery and Radiology, Jewish

Hospital of Brooklyn, and the Department of Radiology, State University of New York, Downstate Medical Center, Brooklyn, N. Y.)

Limited segmental infarction of the small intestine with spontaneous healing is well documented. The authors present 5 cases with similar clinical and roentgenologic features in which the colon is involved. Symptoms of abdominal pain, usually crampy, rectal bleeding and localized abdominal tenderness constitute the clinical findings. Barium enema examination in each case disclosed one or several filling defects along the margin of the colon, which the authors describe as "thumb printing." The lesions have the appearance of intramural extramucosal filling defects. Each patient showed clinical improvement under conservative management, and repeat barium study after intervals ranging from 2 to 10 days demonstrated reversion to normal.

Animal studies were undertaken in an attempt to reproduce the roentgen appearances of these "pseudotumors." Various types of arterial and venous occlusions of vessels supplying the descending colon were produced in dogs. Similar roentgen patterns were obtained. Pathologic examination revealed submucosal hemorrhage with intraluminal bleeding and mucosal ulcers as well as pericolic inflammatory change. The authors feel that the submucosal hemorrhage accounts for the pseudotumor appearance on barium enema examination.

The importance of recognizing reversible vascular occlusion of the colon lies in avoidance of unnecessary surgical intervention in patients who may be elderly and have arteriosclerosis.—David Corbett, M.D.

Gambill, Earl E., Hodgson, John R., and Priestley, James T. Painless obstructive cholecystopathy; hydrops or empyema of the gallbladder: clinical, roentgenologic, and surgical review of 10 cases. A.M.A. Arch. Int. Med., Oct., 1962, 110, 442–448. (From: Mayo Clinic, Rochester, Minn.)

Review of the roentgenologic files at the Mayo Clinic from 1947 through 1957 disclosed 262 cases in which roentgenograms showed what appeared to be obstruction of the cystic duct or "primary shadow of the gallbladder." A "primary shadow" is the shadow of a diseased gallbladder visible on the roentgenogram without administration of contrast medium. A primary shadow is suspected when, after a fat meal, there is no change in density or alteration in the size and shape of a poorly opacified gallbladder.

Ten cases of painless obstructive cholecystopathy produced by a gallstone impacted in the cystic duct were found in 105 surgical patients whose preoperative roentgenograms showed either hydrops or primary shadow. The 10 cases constituted 24 per cent of 42 cases of obstructive cholecystopathy found at operation among the 105 patients.

These patients denied or did not remember having had any abdominal pain either before or after surgery. All were caucasian, and 9 were females. All were afebrile. Epigastric bloating was the most frequent positive symptom and a palpable gallbladder the most common physical finding.

Four illustrative cases are presented. The possibility that the clinical features in a given case of any disease are atypical must be kept in mind if one is to make an accurate diagnosis and hence find a logical treatment.—John D. Hummel, M.D.

Esguerra-Gómez, Gonzalo. El sorbitol como colecistoquinético. (Sorbitol as a cholecystokinetic agent.) *Radiol. Interamericana*, June, 1962, 1, 16–24. (From: Clínica de Marly, Bogotá, Colombia.)

Sorbitol is a substance, first extracted from the fruit of the shrub, *Sorbus*, now synthesized from glucose. It is a white sweet powder with mild laxative effects, which has been put to use by mixing it with a barium meal in gastrointestinal examinations to accelerate the passage of barium through the small intestine. It is also a cholekinetic, used in gallbladder examinations, and has been investigated mostly in France.

The present study is based on 300 cholecystographies, of which 210 were considered normal. The effectiveness of sorbitol as a test agent was gauged by 2 criteria: percentage in reduction of the gallbladder area, and visualization of the hepatic ducts and common duct. After the gallbladder had been visualized, the patient was given 15 gm. of sorbitol dissolved in 60 cc. of ice water; roentgenograms were taken 15 minutes afterwards and, if needed, at 30, 40, and 60 minutes. The gallbladder area was measured by superimposing graph paper over the gallbladder shadow and counting millimeter squares.

The gallbladder contracted by at least 10 per cent in 87 per cent of the patients, and the hepatic and common ducts were visualized in 98 per cent of the patients. To compare sorbitol with the Boyden meal and with cholecystokinine, two groups of 20 patients were examined on consecutive days; they received sorbitol one day and the Boyden meal or cholecystokinine (cecekin, 3 mg. in 10 cc. of saline intravenously) the other day. The percentage decrease in gallbladder area in the sorbitol versus Boyden's meal was: same, 60 per cent; better with sorbitol, 25 per cent; and better with Boyden's meal, 15 per cent.

The comparison of sorbitol with cholecystokinine showed: same, 30 per cent; better with sorbitol, 15 per cent; and better with cecekin, 55 per cent.

The author concludes that sorbitol constitutes a good test agent, because it is harmless, good tasting, nonexpensive, and effective. Cholecystokinine is a much more powerful gallbladder contractor, and its use should be reserved for those instances when the gallbladder has failed to contract or when the bile ducts have not been visualized.—F. Comas, M.D.

WILLIAMS, J. EDMUND. The anomalous cystic duct: a surgical and radiological problem. *Clin. Radiol.*, Oct., 1962, 13, 333–340. (From: Department of Diagnostic Radiology, Royal Hospital, Sheffield, England.)

The cystic and common hepatic ducts usually are bound together by fibrous tissue and may lie parallel to each other for a distance of a few millimeters up to 2 cm. or more before union actually occurs to form the common bile duct, usually within I cm. of the upper border of the duodenum. The cystic duct usually opens on the right side of the main bile duct, but it may enter on the front, the back, or even on the left side. There are 4 main groups of anomalies of the bile ducts: (1) accessory ducts; (2) anomalous length of the common hepatic duct, with either high or low junction of the cystic and common hepatic ducts; (3) anomalous junction of the cystic and common hepatic ducts, including posterior implantation, to the left hepatic duct, to the left side crossing either anteriorly or posteriorly, double spiral around the common hepatic duct, mucosal septum only and absent cystic duct; (4) anomaly of the common bile

The author reports on 10 patients with anomaly of the cystic duct demonstrated by operative or post-operative choledochography. Most of the anomalies were of the low implantation variety. Residual calculi were present in the cystic duct remnant in 6 of these patients.

An enlarged cystic duct stump has been reported by many authors as being a cause of persistent symptoms following cholecystectomy. Jaundice may be a prominent feature and calculi are often found in the remnant of the cystic duct. A cystic duct remnant and "reformed gallbladder" may be the result of inadequate surgery at the time of cholecystectomy, although it is a correct and wise procedure to leave a cystic duct remnant if cholecystectomy is made more hazardous by the presence of edema and inflammation.

Intravenous cholangiography is the best method available for demonstrating the bile ducts before operation if the liver is functioning well and if jaundice is not present. Percutaneous transhepatic cholangiography is the only method other than laparotomy for determining the nature of a biliary lesion in a jaundiced patient. Operative choledochography under the supervision of a radiologist is an essential aid to the complete roentgenographic investigation of calculous biliary tract disease and the detection of anomalies. If an anomalous cystic duct is present and particularly if it is of the relatively common low implantation variety, the drainage tube will be placed in the common hepatic duct rather than in the common bile duct. The cystic duct anomaly can only be recognized roentgenographically if it fills with contrast material in a retrograde manner; hence, calculi hidden within it may easily be overlooked.

The ducts are most easily seen with the patient supine and the position varying between the left anterior oblique and left lateral. A rapid injection is made under fluoroscopic control. A large volume of opaque medium (60–80 cc.) is useful in producing retrograde filling of the cystic duct remnant. A delayed 3 to 5 minute "draining film" is taken to ensure that the dense contrast medium does not obscure residual calculi.—Samuel G. Henderson, M.D.

Lataste, J., and Lalardrie, J. P. La lithiase résiduelle de la voie biliaire principale (À propos de vingt observations). (Residual lithiasis of the main biliary tract [on the basis of 20 observations].) *Presse méd.*, Oct., 1962, 70, 2111–2114. (From: Clinique Chirurgicale de l'Hôtel-Dieu, Paris, France.)

The authors have raised the question as to the origin of calculi found in the common bile duct following cholecystectomy. Are they residues of calculi which were overlooked at the time of operation or are they newly formed calculi?

Based on 20 cases carefully studied they feel that such calculi represent residual or overlooked calculi frequently due to the fact that radiomanometry and cholangiography were not performed or were inadequately carried out at the time of the cholecystectomy. Such residual calculi are more likely to follow emergency cholecystectomy when satisfactory evaluation of the main biliary ducts is not possible or not considered feasible.

The authors believe that the only excuse for the presence of such calculi is the crushing and fragmentation of calculi within the common bile duct or the presence of calculi in the intrahepatic bile ducts which could not be reached or discovered during an operation. When residual calculi are suspected, the proper surgical procedure is an anastomosis between the common bile duct and the digestive tract which would prevent any serious subsequent complications.

Of the many factors which may be considered as causes for residual calculi, the following are most significant: 1. Radiomanometry of the biliary tract was not performed at the time of operation; 2. the films obtained during surgical cholangiography in the operating room were technically inadequate or were incorrectly interpreted; and 3. instrumentation gave a false negative finding.

Reproductions of 6 roentgenograms from selected cases, as well as a table giving a summary of the findings in the 20 cases reviewed by the authors, accompany this article.—William H. Shehadi, M.D.

Ong, G. B., Lee, T. C., Low, Gordon, and Tu, P. Y. Air in the biliary passages of choledochoduodenal origin. *Brit. J. Surg.*, Sept., 1962, 50, 172–178. (From: Kowloon Hospital, Kowloon, Hong Kong.)

Air in the biliary passages may be the result of operative procedures, spontaneous internal biliary fistulae, or infection from gas forming organisms. From 364 cases of cholelithiasis 9 cases of air in the biliary passages are summarized. Eight of these were due to spontaneous choledochoduodenal fistulae caused by impacted radiolucent stones. In the other case a patulous sphincter of Oddi was found which was probably the result of an impacted facetted stone subsequently expelled into the duodenum. All bile cultures were negative for gas forming organisms.

Air in the biliary passages is not common, and not all internal biliary fistulae will produce the condition since the fistula may close as soon as the stone is expelled. The authors state that in the Western literature, the common site of fistula formation reported was between the gallbladder and duodenum, while in their experience choledochoduodenal fistulae were more common. A defense of their position on the most common site is offered in the discussion.—
Francis P. Shea, M.D.

DÉTRIE, PH. L'hépaticité spasmodique; son importance en chirurgie biliaire; étude cholangiométrique. (Spasmodic hepaticity; its importance in biliary surgery; cholangiometric study.) Presse méd., Oct., 1962, 70, 2107–2110. (From: Clinique Chirurgicale de l'Hôpital Cochin, Paris, France.)

The hepatic canal, as designated by the author, is the equivalent of the anatomically defined common hepatic duct extending from the junction of the right and left hepatic ducts to the point of confluence of the cystic and common hepatic and the common bile ducts.

The hepatic canal plays a significant physiologic role which has not been fully appreciated or as yet accepted.

Based on cholangiographic studies, Mirizzi has described a sphincter in this region, which is capable of contraction. This has been substantiated by the anatomic studies of Lang, who described the presence on the hepatic ducts of muscle fibers arranged in a circular and corkscrew manner. This sphincter plays a significant role in the coordinated function of the biliary tract.

Normally in the resting period, in the interdigestive phase, bile flows from the liver through the main bile ducts to the level of the sphincter of Oddi. As the latter is closed bile flows back to the cystic duct and then into the gallbladder. Due to contraction of the sphincter of Mirizzi bile is prevented from flowing back into the main hepatic duct.

The bile flow is actually controlled by the synchronized action of three sphincters, the sphincter of Mirizzi at the lower portion of the common hepatic duct, the sphincter of Oddi at the end of the common bile duct, and the sphincter of Lutken at the cystic duct. During the digestive period bile evacuated from the gallbladder flows into the common bile duct, the sphincter of Oddi, and the duodenum because of the resistance of the sphincter of Mirizzi, preventing bile reflux into the common hepatic duct. In a series of 5 cases the author noted contractions at the level of the sphincter of Mirizzi with transitory narrowing of the common hepatic duct as proof of the above thesis. Furthermore he believes that in cases of "Odditis" and stenosis of the sphincter, the sphincter of Mirizzi is called into further action.

Once the function of the gallbladder has been neutralized through surgical or medical cholecystectomy, synchronization of the biliary function is lost. Odditis will appear and the sphincter of Mirizzi will assume its protective role of the liver by preventing reflux of bile into the hepatic ducts.

Sphincterotomy and sphincterectomy will result in the free flow of bile into the duodenum, the disappearance of back pressure as well as of the contraction of the sphincter of Mirizzi; thus the interdependence of the three sphincters is disrupted.

Cholangiographic studies in the cases presented by the author were performed by catheterization of the cystic duct with the tip of the catheter extending 3 cm. into the common bile duct. Five to six cc. of 75 per cent diodone was injected and films were exposed immediately and 5 and 15 minutes after injection.

Five case reports with reproductions of 16 roentgenograms are presented in support of this interesting thesis.—William H. Shehadi, M.D.

#### GYNECOLOGY AND OBSTETRICS

HSU, CHIEN-TIEN, CH'IU, WEN-HU, and CHENG, YUNG-SHENG. Hysterosalpingograms in cases of ectopic pregnancy. Am. J. Obst. & Gynec., Sept., 1962, &4, 821-824. (Address: 145 Cheng-Chow Road, Taipei, Taiwan, China.)

The authors call attention to the value of hysterosalpingography in the diagnosis of atypical or socalled chronic cases of ectopic pregnancy. The study involves 27 cases of proved ectopic pregnancies with hysterosalpingography. The most important and frequent finding was the intratubal hematocele (blood mole-clot within the dilated tube). This blood mole may be easily demonstrated by hysterosalpingography when the opaque medium enters the tube, coating its surface completely or partially and producing an opaque ring around the blood clot. Sometimes this hematocele may present itself as mulberry figure due to the infiltration of the contrast medium directly into the blood mole itself, especially on 24 hour roentgenograms. A less frequent finding was the demonstration of atonic enlarged uterus with no filling defects and nonvisualization of the tube or tubes.

The diagnostic accuracy of this procedure was 80

per cent to 90 per cent in fresh cases and up to 70 per cent in old cases. The demonstration of the blood mole is almost decisive in the diagnosis of ectopic pregnancy.

This study emphasizes the importance of hysterosalpingography in chronic cases of ectopic pregnancy where the clinical picture may be misleading.—

Leonidas Mostowycz, M.D.

Gerbie, Albert B., and Flanagan, C. Larkin. Gynecologic applications of the radioisotope renogram. Am. J. Obst. & Gynec., Dec. 15, 1962, 84, 1838–1846. (From: Departments of Obstetrics and Gynecology and of Medicine, Northwestern University Medical School and Passavant Memorial Hospital, Chicago, Ill.)

Radioisotope renography is a relatively new and useful procedure for the clinical evaluation of urinary tract disease. Renography is performed by the intravenous injection of radioactive I<sup>131</sup> with external monitoring over each kidney. The greatest advantage of this test over more conventional kidney function tests is its ability to detect unilateral renal or ureteral malfunction by external measurement of radioactivity entering and leaving the kidney region.

The radioisotope renogram as a research aid was used to study urinary tract dysfunction associated with gynecologic operations. During this study, which now includes approximately 60 patients examined renographically both pre- and postoperatively, several clinical gynecologic applications of this test have become apparent. The clinical situations in which the renogram has been of value are: (1) urologic evaluation of patients with pelvic inflammatory disease, endometriosis, and large uterine myomas, pre- and postoperatively; (2) the diagnosis, evaluation, and management of patients with postoperative ureteral impairment; (3) pre- and post-therapy urologic evaluation of patients with carcinoma of the cervix; and (4) the differential diagnosis of postoperative anuria.

Radioisotope renography fulfills the requirements for a practical and applicable clinical laboratory procedure. It is accurate, safe, simple to perform, and inexpensive. Radiation hazards even with serial testing are almost nonexistent. Iodohippurate sodium has a biologic half-life of 20 to 30 minutes. The dose administered is very small and 50 to 75 per cent is excreted within 25 minutes after injection. There have been only 2 allergic reactions, both minor, in the approximately 1,500 radiohippuran renographic studies which have been done at the Northwestern University Medical School.

It must be emphasized that, since renography is a relatively new procedure, the complete range of normal variation remains to be determined. One must not attempt to read too much into the graphs; the wave form is of primary importance and differences in magnitude alone are usually not significant.— Eugene J. McDonald, M.D.

FREEDMAN, HENRY L., TAFEEN, CARL H., and HARRIS, HERBERT. Conjoined thoracopagous twins: case report. Am. J. Obst. & Gynec., Dec. 15, 1962, 84, 1904–1909. (From: Department of Obstetrics and Gynecology, Long Island College Hospital and the State University of New York Downstate Medical Center, Brooklyn, N. Y.)

In the approximately 80,000 births recorded at the Long Island College Hospital since 1921, there has been only I case of conjoined twins. According to Hill, female thoracopagous twins occur 3 times as frequently as males. The diagnosis of thoracopagous twins is difficult, particularly when they present as vertices where Gray's roentgenographic criteria do not apply. In this modern era, cesarean section is far less hazardous to the mother than complicated and extensive blind intrauterine manipulations. This point is emphasized because of the size of the infants.

The single case is well presented with dates and close follow-up. An abdominal roentgenogram at 5 months showed hydramnios and a single fetal skull. At 8 months a twin pregnancy was demonstrated with one head as a vertex. Several days later labor progressed and the head and shoulders of one fetus were delivered and no further progress was made. Manual examination confirmed the diagnosis, a cesarean section was performed and twins were delivered.

Pathologic discussion and photographs complete this unusual case report.—Eugene J. McDonald, M.D.

#### GENITOURINARY SYSTEM

Coliez, Robert T. (Paris, France.) La nécrose papillaire du rein. (Papillary necrosis of the kidney.) J. de radiol., d'électrol. et de méd. nucléaire, June–July, 1962, 43, 361–373.

This disease, first described by Von Friedreich in 1877, has been better known since Günther's work in 1937.

The lesion is the result of a necrosis which is limited to the papilla and the distal portion of Malpighi's pyramids. Microscopic examination reveals necrosis by coagulation, characteristic of an infarct, with important cellular alterations. The necrotic area is invaded by numerous inflammatory cells and is surrounded by a zone of congestion and bacteria. Several vascular thromboses are seen in and around the necrotic area. The entity is best characterized as an ischemic sequestration or degenerative necrosis involving, amidst an interstitial necrosis, all or part of the renal papillae distal to the corticomedullary junction. The necrotic zone assumes a nodular form which, becoming detached, behaves as a foreign

body. This explains the lacunar shadow in the center of an enlarged papilla. The renal cortex and Bertin's columns are often involved by interstitial nephritis.

The cavities thus created are of two types, papillary or medullary, according to their formation at the expense of the extremity of the papilla, or of a larger portion of the pyramid. The medullary cavities are round or oval, while the papillary ones are triangular with a bulging base. Shrinkage of the whole kidney accompanies these papillary sequestrations and if the lesions are bilateral, the renal contraction is strictly identical. Histologically, all kidneys with papillary necrosis show a chronic pyelonephritis. The process may be unilateral or bilateral.

In 33 per cent of the cases, these necrotic papillae may calcify. They produce pseudocalculi with a radiolucent center, composed of the necrotic papillary fragment surrounded by a rim of calcium. This explains the annular calcifications visible on plain roentgenograms. Usually, these calcifications are produced when the fragment is infected by *B. proteus*.

The pathogenesis of this ischemic necrosis is not completely established. A vascular disorder appears probable, since there normally exists a relative ischemia in the renal papillae and Malpighi's pyramid, the vascularization of which is provided only by the afferent arterioles from the juxtamedullary glomeruli. The factors mostly responsible are diabetes mellitus, obstructions of the urinary tract or the use of barbiturates, sulfamides, or phenacetin base somniferous drugs.

The clinical picture is extremely variable: lumbar pain, dysuria or pollakiuria, hematuria, fever, chills, azotemia. In the acute septicemic form, the outcome is almost always fatal. Subacute forms may last a few weeks or months. The chronic forms have been well studied by Nils Lindvall who, by following cases over periods of 5 to 20 years, has shown the progression of the lesions from minimal to full-blown stages.

For the roentgenologic diagnosis, intravenous urography with prolonged compression is the method of choice except if the renal function is seriously impaired, in which instance retrograde pyelography should be resorted to.

Roentgenologic manifestations vary according to the advance of the disease. At first, there is a slight dilatation of the calyceal fornix, with irregular and blurred contour of the papilla. Contrast medium may permeate the parenchyma, which is a premonitory sign of an incipient papillary sequestration. Concentration of the opaque substance is diminished. The papillae then become dilated and appear round or oval if a medullary cavity has formed, or triangular if due to a papillary cavity. These cavities eventually become enlarged by insufficient drainage or destruction of papillary tissue.

Sometimes calyces become clubbed. Papillae then become blurred or sloughed and this stage corresponds to early papillary detachment. Once this detachment is complete, the opaque medium surrounds the papilla and produces a ring shadow which is generally triangular; at a later stage, annular or triangular calcifications make their appearance. Slight hydronephrosis and ureteral changes may be observed similar to those seen in ureteritis and pyelonephritis (numerous strictures and dilatations).

In the differential diagnosis, the author discusses tuberculosis, calyceal diverticula and cysts, medulary sponge kidney, pyelonephritis without papillary necrosis, hydronephrosis, pelvic tumor, and renal reflux.—H. P. Lévesque, M.D.

Wax, Sandor H., Frank, Irwin N., and McDonald, Donald F. The usefulness of the radioactive hippuran renogram in the differential diagnosis of azotemia. J. Urol., Sept., 1962, 88, 433–437. (From: Division of Urologic Surgery, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.)

Patients with azotemia of unknown etiology are usually not candidates for evaluation by intravenous urography and in many instances retrograde pyelography is contraindicated. The authors present an alternate method of differential diagnosis; namely, the radioactive hippuran renogram. In previous reports, these same authors have analyzed the renogram by breaking it down into its basic components. The nonfunctional components are tissue radioactivity other than kidney and radioactivity emanating from blood flowing through the kidney. The functional components consist of radioactivity contributed by tubular secretion and glomerular filtration. Utilizing I<sup>131</sup> albumin before and after nephrectomy, it was concluded that the normal I<sup>131</sup> hippuran curve at maximum height comprised 15 per cent background, 10 per cent renal vascularity and 75 per cent functional component. When probenecid was used to block the tubules, further analysis revealed 60 per cent of the maximum height of the curve was accounted for by tubular secretion and 15 per cent by glomerular filtration.

The 3 phases of the radioactive hippuran renogram are the background phase, the functional phase, and the emptying phase. Forty patients with azotemia had diagnostic renograms analyzed according to this method. The authors found that the radioactive hippuran renogram was a valuable, safe, and accurate method of studying the well hydrated azotemic patient. The presence of a good functional phase and evidence of prompt drainage reflects the lack of obstruction. Good function and a rising curve is present in the face of obstructive disease. In such instances further urologic evaluation is indicated. Poor function with a low, flat drainage segment denotes marked reduction in renal function usually of an irreversible nature.

Six diagrams and 1 chart are used to illustrate this article.—George W. Chamberlin, M.D.

Munk, J., and Hahn, E. The radiological differentiation of the small kidney in hypertension of renal origin. *Clin. Radiol.*, Oct., 1962, 13, 265–286. (From: X-Ray Department, Rambam Government Hospital, Haifa, Israel.)

This study was made to investigate whether there are roentgen features which would make it possible to distinguish between: (a) the small kidney in renal artery stenosis; (b) the pyelonephritic (atrophic) kidney; (c) the congenital hypoplastic kidney; and (d) the congenital hypoplastic kidney with superimposed pyelonephritis. The study included 31 cases of hypertension considered to be of renal origin. In 21 of these cases a unilaterally small kidney was found, the difference in length between the 2 kidneys varying between 3 and 6.2 cm. in 16 cases, and between 1.5 and 3 cm. in 5 cases. The roentgen signs on plain roentgenography, intravenous urography, retrograde urography, presacral insufflation with laminagraphy, and renal angiography were considered. The authors were particularly interested in determining whether there was a relationship between the size of a kidney and its functional manifestations (excretion time and contrast material density) on intravenous urography, and whether one could draw any conclusions concerning the structural damage to a kidney from its size and from its functional behavior.

In renal artery stenosis the small kidney shows a smooth and regular outline with marked reduction of the size of the kidney and marked diminution of the renal substance. The excretion time is found to be normal in cases in which the length of the small kidnev has not decreased by more than 3 cm., and in these cases the contrast density is equally good bilaterally or is increased on the affected side. This is the ischemic kidney, with no marked structural damage. In the ischemic kidney, with marked structural damage (atrophy) where the length of the involved kidney is 3 cm., or more, less than the opposite kidney, there is no excretion or markedly delayed excretion with poor contrast density. The calyces in this group are spastic, and Sutton et al. consider this to be an important sign. Renal angiography is very helpful in detecting these cases in their early stages.

In chronic pyelonephritis the small kidney presents irregularly located depressions, the relative width of which is not uniform and varies in different parts of the same kidney. The small kidney is apt to be in a vertical position near the vertebral column. There is either no excretion or very delayed excretion with very poor contrast density. While the calycine system usually shows calyceal spasticity, loss of cupping and flat papillae, a normal appearance does not exclude early chronic pyelonephritis. Varying degrees

of ureteral dilatation, segmental or total, unilateral or bilateral, and in children a vesicoureteral reflux, are commonly seen.

In the congenital hypoplastic kidney the difference in length between the 2 kidneys was never less than 5 cm. The outline was smooth and regular. There were 2 types of roentgen appearance. In 1 there was a very small kidney with normal excretion, good contrast density, marked bizarre deformity of the calyces, a small pelvis, and a thin ureter. In the other, the "miniature kidney," there was normal morphology of the calyces with reduction in size proportional to the small size of the kidney, and with width of the renal substance proportional to the size of the kidney and its calycine system.

In the roentgen differentiation of the congenital hypoplastic kidney on which chronic pyelonephritis is superimposed, there are no criteria which permit distinguishing between the morphologic changes in the calycine system in these two conditions.—Samuei G. Henderson, M.D.

Halikiopoulos, H. J., Ballou, Lillian, and McDonald, D. F. The excretory urogram and radiographic kidney size as screening devices in hypertension of unilateral renal origin. J. Urol., Oct., 1962, 88, 456–458. (From: Division of Urology, University of Rochester, Rochester, N. Y.)

Fifty-two hypertensive and 50 normotensive patients were compared from the standpoint of renal mass as measured on roentgenograms and the density of excreted contrast material in the excretory passages. Complete diagnosis in the hypertensive group was established by renal function tests, aortography, surgical exploration, and histopathology. The length, width, and kidney area in square centimeters were determined from the roentgenogram by the planimeter method. The nephrogram density on the earliest roentgenograms and the concentration of contrast medium on subsequent excretory roentgenograms were compared on the 2 sides. Five groups of patients were recognized.

The essential hypertension group included 18 patients. The difference in length of the kidneys was less than 1 cm. in 15 and greater than 1 cm. in 3. Seventeen of the 18 showed equal concentration and nephrograms bilaterally.

Main renal artery occlusive disease was present in 17 patients. The difference in size between the 2 kidneys was greater than 1 cm. in 13 cases, less than 1 cm. in 3 cases, and equal in 1 case. The density of the nephrogram on the affected side was decreased in 16 out of 17 instances and equal in 1 instance. A difference in the contrast medium density in the excretory urograms was not as frequent a finding as disparity in size and density of nephrograms.

Six patients had segmental renal artery disease. The disparity in size of the 2 kidneys was greater than I cm. in 50 per cent of the cases. The concentration on the affected side was increased in 2 cases, decreased in I, and equal in 3. The nephrogram was decreased on the affected side in 5 out of 6 patients with this type of renal artery disease.

Seven patients were included in the renal artery aneurysm group. Six of the 7 showed that the involved kidney was more than 1 cm. diminished in size compared to the normal kidney. The nephrogram on the affected side was decreased in 5 of the 7 instances. Concentration of contrast medium on the affected side was increased in 5 instances.

The hypoplastic kidney group with hypertension included 4 patients, all of whom had decreased concentration or a nonfunctioning kidney on the affected side with disparity in size greater than 1 cm.

On the basis of these studies the authors feel that, in spite of previous communications to the contrary, the excretory urogram when properly and carefully interpreted does perform a definite function as a screening device in patients with hypertension of unilateral renal origin.—George W. Chamberlin, M.D.

KARANI, S., MORRIS, L., and RUSSELL, I. Angioma of the renal artery causing hypertension. *Clin. Radiol.*, Oct. 1962, 13, 287–289. (From: The Departments of Medicine and Radiodiagnosis, St. Nicholas' Hospital, Plumstead, London, S.E. 18, England.)

Angioma of the renal artery is a rare lesion, and the authors found only 3 similar cases, investigated by aortography, reported in the literature.

In the case here reported, that of a young man of 27 with blood pressure of 255/130 mm. Hg and papillitis of both ocular fundi, aortography revealed an extensive cirsoid vascular malformation of the right kidney hilus. A small similar malformation was present on the surface of this kidney, and there was a tortuous vessel along the line of the right ureter, representing a cirsoid malformation of the ureteral artery. A roentgenogram made during the pyelographic phase revealed deformity of the right renal pelvis and upper ureter.

In the article it is stated that a "left nephrectomy was performed." Presumably this is a typographical error. On pathologic examination there was a tortuous vessel in the kidney hilus. Kidney sections revealed some degree of irregular thickening of the intima of the arteries, with some medial hypertrophy.

The cause of the hypertension is thought to be suppression of blood flow to the kidney due to the vascular malformation, as well as some degree of prerenal shunting due to an arteriovenous fistula. The latter is suspected because of apparent early filling of the inferior vena cava on one of the roent-genograms.

Twelve weeks after operation the patient's blood pressure was 180/85 mm. Hg. The fundi were clear,

the patient felt well and was back at work.—Samuel G. Henderson, M.D.

Fauré, C., Verspyck, R., Parienty, R., and Salomon, A. Les anévrysmes du pédicule rénal (revue générale et présentation de 11 cas). (Aneurysms of the renal pedicle [general review and presentation of 11 cases].) J. de radiol., d'électrol. et de méd. nucléaire, Oct., 1962, 43, 583-595. (From: Service de Radiologie, Hôpital des Enfants Malades, Paris, France.)

Aneurysms of the renal pedicle can be true saccular lesions or false pulsating aneurysms in a hematoma; can be fusiform (jet lesions), dissecting, arteriovenous, or cirsoid; occasionally they are multiple. No age is exempt. Etiology ranges through congenital malformations, atherosclerosis, inflammation and trauma. Roentgenographically they may be diagnosable on plain roentgenograms as ring-like calcifications, usually between 1 and 2.5 cm. in diameter; they can cause a deformed appearance of the pyelocalyceal system on pyelograms, but are best demonstrated on aortograms. They can be situated on the trunk or a branch of the renal artery. Their clinical importance rests on their relationship to arterial hypertension, thrombosis or rupture.

The differential diagnosis includes consideration of ganglionic calcifications, biliary stones, osteochondroma of the lumbar spine, renal parenchymatous or hilar calcifications, calcified hematoma, tuberculous abscess, intrarenal cyst, calcified malignant lesions, and aneurysms of splenic, hepatic, pancreatic or mesenteric vessels. Simple poststenotic dilatation is differentiated by locating the narrowed lesion. Arteriovenous aneurysms pose only the question as to whether they are on the renal artery or other vessels.

Exact roentgenographic localization is important since treatment is surgical and the aneurysm may be difficult for the surgeon to find. Usually a nephrectomy is required.—Frank A. Riebel, M.D.

Thurn, P., Fritz, K. W., Düx, A., and Heymer, A. Renal arteriography in the diagnosis and therapy of renal hypertension. *German Med. Month.*, Oct., 1962, 7, 332–334. (From: The Department of Medicine, University of Bonn, Bonn, Germany.)

The authors state that renal arteriography should be performed in all hypertensive patients, especially in the younger age group where the etiology of hypertension cannot be satisfactorily explained by other diagnostic methods. They believe that retrograde aortography is preferable to the translumbar method, the latter method being indicated only if severe sclerosis or stenosis of the renal arteries is present. Both kidneys should be visualized in order not to overlook any bilateral involvement, and late roent-

genograms should be taken to demonstrate venous return.

Extrarenal and intrarenal obstruction of the renal artery may be demonstrated by renal arteriography. Unilateral and bilateral stenosis is surgically correctable and may eliminate hypertension. The methods used and the indications for renal arteriography in hypertension are discussed. Case reports of 8 patients are included.—Douglas S. Kellogg, M.D.

Cooley, R. N., and Derrick, J. R. Angiography in the detection of renal arterial obstruction. *South. M. J.*, Dec., 1962, 55, 1235–1245. (From: Departments of Radiology and Surgery, The University of Texas Medical Branch, Galveston, Tex.)

This study was undertaken mainly to evaluate the adequacies and shortcomings of aortography and angiography in demonstrating arterial obstructions as confirmed by operation. Out of a total of 350 patients who had lumbar aortography or renal arteriography, there were 79 patients studied in whom the major medical problem or major cause of symptoms was hypertension. In 60 of this group there was angiographic evidence of obstruction to the renal arterial system. Twenty patients had subsequent surgical exploration and treatment for arterial obstruction.

The angiographic findings in this group were compared with pressure gradients in the involved arteries, the appearance of the kidneys, and in some instances the postoperative course of the patient. In 2 cases, an apparent obstruction seen at aortography was not found, and in 2 other cases, kinking or torsion of a segmental artery was not anticipated or diagnosed. Partially occluded aberrant or supernumerary arteries were not seen in 2 cases. In 2 other cases, failure of one or more segments to show a good nephrogram led to a correct diagnosis.

The following conclusions are presented: (1) no single procedure or test now available can exclude the presence of renal ischemia; (2) the presence of a positive split function test associated with the demonstration of a unilateral arterial obstruction is a favorable prognostic sign if surgical therapy is satisfactory; (3) translumbar aortography as ordinarily performed occasionally does not reveal localized arterial obstruction and cannot exclude such a lesion. Selective aortography and/or arteriography with serial roentgenography over a period of 10 to 15 seconds is a more reliable means of studying the renal circulation; and (4) whether surgical exploration should be carried out when all the above mentioned means of appraisal of the renal circulation are negative remains unanswered.—William C. MacCarty,  $\mathcal{F}r., M.D.$ 

TRISTAN, THEODORE A., MURPHY, JOHN J., and Schoenberg, Harry W. Cinefluorographic investigation of genitourinary tract

function: a combined simultaneous and synchronous cinefluorography and intravesical manometry in the evaluation of neurogenic bladder function and bladder outlet obstruction. *Radiology*, Nov., 1962, 79, 731–739. (Address: 3400 Spruce St., Philadelphia 4, Pa.)

Many clinical and basic studies have contributed to our knowledge of the mechanisms of ureteral reflux and bladder outlet obstruction. A number of investigators have devised techniques of a roentgenologic or cystometric nature that often allow the demonstration of these abnormalities. However, our knowledge of the etiologies of these destructive uropathies, which present a wide spectrum of manifestations, is incomplete and the lack of an etiologic classification and rational therapy is a basic factor in the somewhat poor results of treatment.

To further clarify such basic factors in genitourinary tract dysfunction, the authors report the method and results of a combined and simultaneous cinefluorographic and intravesical manometric examination in both children and adult patients. The bladder in cooperative patients (children are lightly anesthetized) is catheterized and filled with 50 per cent hypaque. The volume used ranges from 50 cc. for a reflex (upper motor neuron) bladder, to 700 cc. or more in an autonomous (lower motor neuron) bladder. Usually 125 to 300 cc. is employed. Once the bladder is distended above the symphysis, a polyethelene catheter is introduced by percutaneous suprapubic puncture with 17 gauge thin walled needle. The catheter is then connected to a strain gauge with a recorder and the record is marked simultaneously by signals from the motion picture camera motor, allowing later comparison studies. Thus, with sufficient patience and time, combined cinefluorograms and direct cystometrograms are obtained during micturition. Fifty-five patients have been studied in this manner: 15 of the number had neurologic disorders; the remaining 40 were children referred because of recurrent pyuria or because reflux had been suspected or discovered elsewhere.

In the normal patient the cystometrogram presents a smooth pressure curve rising to about 25 to 30 cm. of water pressure while the cinefluorographic cystourethrogram shows smooth detrusor activity and sharply defined muscular activity of the bladder neck. Studies of the reflex neurogenic bladder show uncoordinated activity with small increases in pressure superimposed on an elevated baseline in the resting stage. Muscular activity of the detrusor is irregular and asynchronous with micturition occurring in an interrupted manner. In contrast, the resting pressure in an autonomous neurogenic bladder is low, with overflow urination occurring with small increases in pressure and no clear cut detrusor activity.

A broad range of abnormality is noted with this

technique in children with lower urinary tract dysfunction. The findings in those cases with abnormal narrowing of the bladder neck and posterior urethral dilatation are especially interesting and obvious. The cystometrogram reveals a high voiding pressure imposed upon a high resting pressure, while the voiding cinefluorogram shows a ridge or thickening of the bladder neck and bulging of the anterior wall of the posterior urethra. This pronounced anterior bulging, or pseudodiverticulum, is noted to develop as the intravesical pressure rises and maximal size coincides with the peak voiding pressure. Not all patients with these findings show ureteral reflux, but it is encouraging that voiding pressures and urethral outlines are in the normal range after bladder neck resection. Those patients who do not show this anatomic change or who have only a slight degree of change, have responded to antibacterial therapy or urethral dilatation. Therefore, an accurate diagnosis of the site of abnormal anatomy and physiology must be established to allow successful, rational therapy.—Edward B. Best, M.D.

RHAMY, ROBERT K., GARRETT, ROBERT A., and CARR, JAMES R. Cineradiographic characteristics of intravesical obstruction. J. Urol., Nov., 1962, 88, 696-699.

Cineroentgenography offers an addition to our diagnostic armamentarium for studies of the lower urinary tract. In children, this is an excellent method for the evaluation of vesicoureteral reflux and visualization of the functional anatomy of the vesicourethral area during the voiding process.

One hundred forty-two children without neuromuscular dysfunction were studied by the authors because of disturbances in micturition or to evaluate urinary tract infection. Thirty-five of these patients had vesical neck obstruction. Seven demonstrated posterior urethral valves and 24 were diagnosed as stenosis of the urethral meatus.

The roentgenographic studies were carried out under fluoroscopic guidance using image amplification and cineroentgenography. The bladder was gently distended with 20 per cent contrast medium and during fluoroscopy evidence of ureteral reflux was obtained by rotating the patient into the oblique positions. The patient was then tilted to the erect position, the small catheter removed and cineroentgenography was performed during the voiding act.

Only about one-fourth of the patients had significant bladder residual urine, but in some instances there were residua in the upper urinary tracts. In the male patients with vesical neck obstruction, there was either a circumferential contracture or an elevated posterior lip deformity at the vesical neck. In female patients, usually a circumferential contracture was evident. Anterior lipping alone was not common and when seen did not usually indicate severe damage of the same degree as the other types

of bladder neck obstructions. A configuration of the bladder in which the height was greater than the width was suggestive of vesical neck obstruction. The urethra distal to the site of obstruction was normal in caliber. Ureteral reflux was observed in 54 per cent of the patients who exhibited vesical neck obstruction. The motility of the ureters was more or less proportional to the degree of dilatation. Saccules at the ureterovesical junction were noted in patients with obstructive vesical ureteral regurgitation.

Patients with posterior urethral valves had a dilated prostatic urethra with a secondary vesical neck contracture. In such instances, the degree of obstruction was usually great, and the patients tended to exhibit an intermittent voiding pattern.

In those instances of stenosis of the female urethral meatus, there was usually a normal bladder contour. The urethra showed dilatation but the vesical neck was normal and very little or no residual urine was noted. In spite of the normal bladder contour, 16 of 26 patients with stenosis of the urethral meatus showed evidence of vesical ureteral regurgitation with normal ureteral motility.

Four cineroentgenographic illustrations show the roentgen appearance of the obstructive vesical and urethral lesions.—George W. Chamberlin, M.D.

COCKETT, ABRAHAM T. K., BEEHLER, CECIL C., and ROBERTS, JAMES E. Astronautic urolithiasis: a potential hazard during prolonged weightlessness in space travel. J. Urol., Oct., 1962, 88, 542–544. (From: Experimental Surgery Department and the Biokinetics Branch, School of Aerospace Medicine, U.S.A.F. Aerospace Medical Division (A.F.S.C.), Brooks Air Force Base, Tex.)

In addition to the usual etiologic factors in urinary lithiasis, such as stasis, infection, diet, foreign body, metabolic abnormalities, lesions of the renal papilla, emotional stress, and physiochemical factors, the astronaut is exposed to serious metabolic shifts in calcium and phosphorus metabolism during prolonged space travel. These metabolic changes are brought about by relative immobilization subsequent to muscle inactivity augmented by the absence of the gravity factor. The end result is a stimulus to greater decalcification of the osseous system and an increase in urinary calcium excretion.

Prophylactic measures should include a vigorous in flight program of physical exercises employing spring devices to maintain normal muscular activity, rotation of space craft to create artificial gravity, avoidance of overexposure to ultraviolet light, and limitation of excessive dietary calcium with the inclusion of dietary oral resins specific for the prevention of hypercalcemia. An adequate oral fluid intake, approximately 3 liters a day, may be the single most important prophylactic measure. Rigid voiding schedules to prevent urinary stasis should be en-

couraged. Indwelling urinary catheters should be avoided to prevent infection and incrustation.—
George W. Chamberlin, M.D.

TANCER, M. LEON, and HYMAN, RICHARD. Suburethral diverticulitis in the female. Am. J. Obst. & Gynec., Dec. 15, 1962, 84, 1853–1858. (From: Departments of Gynecology and Urology, the French Hospital, New York, N. Y.)

Suburethral diverticulitis is a chronic disease which originates from the posterior wall of the proximal half of the urethra. It involves the tissue space between the proximal half of the urethra and that portion of the anterior vaginal wall subjacent to it. The urethra is a tube averaging 4 cm. in length. It acts as a conduit for the passage of urine from the bladder and can play a role in the maintenance of continence. The distal half is intimately adherent to the anterior vaginal wall.

The urologist frequently considers the urethra to be a supporting mechanism for the admission of the cystoscope into the bladder, and fails to examine the anterior vaginal wall digitally. His index of suspicion for lesions of the trigone, bladder, and ureters is many times higher than it is for lesions which may involve periurethral structures, and it is an infrequent situation that causes him to avail himself of the gynecologist's special talents for vaginal examination. The gynecologist who is faced with a presenting symptom of dyspareunia or chronic pelvic discomfort may fail to question the patient carefully about recurrent urinary symptoms and, on pelvic examination, is prone to investigate the introitus, the vaginal sulci, the uterus, and adnexae carefully. It is infrequently that he invokes his urologic colleague's ability to accomplish urethroscopic and, perhaps, urethrographic techniques.

Several reports fail to mention the use of urethrography as an adjunct in the diagnosis of suburethral diverticulitis. The lesions described in these reports are always large and acutely infected. The authors believe there are smaller and less acute lesions which frequently are overlooked. Davis and Cian, using positive pressure urethrography, found 12 new cases in a 2 month period in women who complained of recurrent cystourethritis. Only 2 patients had palpable masses and one of the patients had had a cystoscopic examination 27 times previously. Urethrography should be used in the study of the obvious case as well, since knowledge of the extent of the lesion is important in planning therapy. Positive pressure urethrography was performed with the Trattner catheter, modified by Hyman, for minimizing the contrast medium leakage into the bladder. The stylet was used to introduce the catheter into the bladder and each balloon was filled with 35 to 40 cc. of air. The contrast medium is a mixture of 20 per cent methiodal sodium and an equal amount of lubricating jelly. Approximately 8 to 10 cc. of the contrast medium was inserted into the catheter under moderate pressure.

Partial ablation of the infected sac is advised in cases in which total excision increases the probability of injury to the proximal urethral floor, the vesical sphincter, or the trigone.—Eugene J. McDonald, M.D.

#### SKELETAL SYSTEM

LAW, W. ALEXANDER. Late results in vitallium-mold arthroplasty of the hip. J. Bone & Joint Surg., Dec., 1962, 44 A, 1497–1517. (Address: Consultant Orthopaedic Surgeon, The London Hospital, The Robert Jones and Agnes Hunt Orthopaedic Hospital, and the Tilbury Riverside Hospital, London, England.)

The author presents his results in a personal series of consecutive cases of mold arthroplasty using the Smith-Peterson technique, over the period of 12 years between 1947 and 1958. This series included 566 hips in 467 patients which consisted of 429 cases of osteo-arthritis, 28 patients with rheumatoid arthritis and ankylosing spondylitis and 10 cases of old septic arthritis.

Of 135 patients with 178 hips who were operated on 10 years or more previously, 137 were osteoarthritic. The remainder consisted of old congenital dislocations, Otto pelves, traumatic arthritis, rheumatoid arthritis and old infective arthritis. In this group excellent and good results occurred in 62.5 per cent, fair results in 28.5 per cent and poor results in only 9 per cent. In the rheumatoid group which included cases of ankylosing spondylitis there were no excellent results. The number of good and poor results was about the same.

The alleviation of pain is the main indication for this procedure in most patients. There are two components of pain in most cases, articular and muscular. The true joint pain is ordinarily relieved immediately after operation. The pain of muscle origin is due to loss of tone and substance. It is relieved by progressively active use with intervening periods of rest.

Patients with bilateral operations are naturally slower and less agile than those with unilateral operations, and their rate of progress must be adjusted accordingly. The range of movement achieved by this operation in osteo-arthritis usually lies between half and two-thirds the normal in a single hip, and between a third and half the normal in bilateral cases. In some cases a much longer period is required than the 3 to 6 months after operation usually necessary. Patients may improve steadily for as long as 5 years after surgery, and there will be a gradual transition from a fair to a good classification.

In the author's series the operative mortality is 2.5 per cent. Pulmonary embolism and thrombophlebitis are the most frequent complications and preventive measures should be taken where possible. In the

immediate postoperative period, encouraging the patient to move about in bed and the regular performance of simple static and breathing exercises is important. The limb must not be allowed to fall into external rotation during the first 5 weeks after operation. Infection is a complication indicating faulty surgical technique and should be avoided. The author believes that failure to reconstruct the new joint surfaces at the level of healthy cancellous bone, an incorrect size of mold, a mold which is not inert, and excessive capsule resection should be avoided.—
J. N. Ané, M.D.

Thompson, Frederick R., and Sezgin, M. Ziya. (New York, N. Y.) Polyurethane polymer: an experimental investigation of its adjunct value in the treatment of fractures and in arthrodesis. J. Bone & Joint Surg., Dec., 1962, 44A, 1605–1620.

The authors began their study of the polyurethane polymer, known as ostamer, with the idea that the material had great value. Employing rabbits, a fairly thorough study of the use of the plastic in the fixation of fractures, spinal fusions and tissue reactions resulted. Various methods of preparation and employment of the material were investigated.

New bone formation did not occur in rabbits within 12 weeks of implantation. The typical reaction was a fibrous tissue response, often inflammatory. Infection occurred in 20 per cent of the rabbits. Polyurethane softened within the body and usually required metallic reinforcement. The heat of the chemical reaction of polyurethane fast-mixed at 120° F. rose so that it coagulated proteins. In all experiments both the roentgenograms and the microscopic slides demonstrated that the polyurethane in rabbits acted chiefly as a barrier to normal bone formation during fracture healing. The new bone formation observed was subperiosteal and extracortical, as is usually seen in osteomyelitis as the old cortex was dead.—J. N. Ané, M.D.

Redler, Irving. Polymer osteosynthesis: a clinical trial of ostamer in forty-two patients. J. Bone & Joint Surg., Dec., 1962, 44A, 1621–1652. (From: Department of Orthopaedics, School of Medicine, Louisiana State University, New Orleans, La.)

Mandarino and Salvatore first reported the use of a polyurethane polymer, ostamer, in 1958 for osteosynthesis. Animal experiments reported by these investigators demonstrated progressive osteoblastic replacement of the plastic by host bone. No evidence of local or host systemic toxicity was observed.

Forty-two patients were carefully chosen to determine the suitability of this method for specific therapeutic problems. This study was started by the author in February, 1959 and 51 operations were

performed on the 42 patients. The polyurethane polymer was used in 19 arthrodeses and for the fixation of 6 fresh fractures, 3 pathologic fractures, 19 fractures with nonunion and 3 osteotomies and in 1 case with a tibial bone defect.

Of the 51 operations, 9 gave successful results. Failure of fixation in 37 cases was due to breakage of the polymer column or loosening of the plastic mass within the bone. An extremely high incidence of wound infection and draining sinuses was encountered in the series. Microscopic examination of specimens of the polymer removed never demonstrated any evidence of osteoblastic activity, even 27 months after its implantation. The author is of the opinion that the use of polyurethane polymer for osteosynthesis is not recommendable at this time.

Polyurethane polymer is radiolucent but portions of it projecting outside of the bone cavity can be differentiated from adjacent soft tissues. Callus was observed from 6 to 8 weeks after operation and it was noted subperiosteally on the cortical surface opposite the polymer. It was never seen on the superficial surface of the plastic. In some patients a calcific shell over the superficial surface of the polymer from the proximal cortex was noted. Obliteration of the bone cavity containing the polymer was never observed.—
J. N. Ané, M.D.

RHINELANDER, FREDERIC W., and BARAGRY, RICHARD A. Microangiography in bone healing. I. Undisplaced closed fractures. J. Bone & Joint Surg., Oct., 1962, 44A, 1273–1298. (From: The Department of Orthopaedic Surgery, Western Reserve University School of Medicine and Cleveland Metropolitan General Hospital, Cleveland, Ohio.)

The authors produced undisplaced fractures in the forelimbs of dogs which were sacrificed at different stages of healing. The forelimbs were perfused through the brachial artery with micropaque (a finely divided barium sulfate). The limbs were then fixed with formalin and later the soft tissues were removed down to the periosteum. The bones were decalcified and sliced longitudinally through the fracture sites into 1 mm. thick sections to be examined by roentgenography and microscopy. Stereoscopic microangiograms were made of each 1 mm. slice and studied.

It was found that in undisplaced fractures the major blood supply to the healing fractures was derived from the medullary arteries rather than from the periosteal vessels. Even the external callus formation received its major nutrition from the medullary vessels. Usually the amount of callus formed varied inversely with the degree of immobilization. The formation of cartilage at the fracture site also was thought to be due to inadequate immobilization. Fractures that healed promptly showed a minimum of callus and fibrocartilage. Delayed union usually

was associated with more extensive callus and fibrocartilage formation.

There was a sustained increased blood flow to the injured limb. The periosteal blood supply can take over if the medullary supply is interrupted. The medullary supply can become re-established within I week after it is completely interrupted.—Frank M. Windrow, M.D.

Janes, Joseph M., Kelly, Patrick J., Herrick, Julia F., and Peterson, Lowell F. A. The effect of high-dosage ultrasonic energy on femora of the dog; a roentgenographic, histological, and microangiographic study. J. Bone Joint Surg., Oct., 1962, 44A, 1299–1307. (From: The Section of Orthopedic Surgery and the Section of Biophysics, Mayo Clinic and Mayo Foundation, Rochester, Minn.)

As part of a continuing study of the effects of ultrasonic energy on bone, the authors subjected the mid femora of 13 live dogs to larger than clinical doses of ultra sound. The dogs were followed roent-genographically during life, then sacrificed and the specimen studied after vascular injection, by dissection and histologically.

The roentgenograms showed a medullary lucency which appeared about 2 weeks after exposure, corresponding to histologic evidence of general tissue necrosis. Two to three weeks later periosteal new bone formation appeared at the proximal and distal ends of the rarefaction. In the next 2 to 4 weeks the rarefaction either gradually filled in and appeared normal or the cortex became thinner at the sites of periosteal reaction and eventually fractured.—H. J. Klos, M.D.

JERRE, TORSTEN. Dysplasia epiphysialis punctata. *Acta orthop. scandinav.*, 1962, 32, 315–323. (From: The Orthopaedic Clinic, Västerås, Sweden.)

The author presents a case with a brief review of the literature. A white girl was seen at the age of I month because of malposition of the right knee. Typical changes of dysplasia epiphysialis punctata were present in the right lower extremity, including the pelvis, hip, knee and ankle; the remaining bones appeared normal. The changes regressed in an orderly fashion over the next 2 years, with regression first in the most proximal area and last in the most distal area. At the age of 3, the patient had a persistent valgus deformity of the right knee and a 4 cm. shortening of the right lower extremity, but was otherwise normal.

The roentgen changes are usually sufficiently characteristic to be diagnostic. Small calcifying areas are seen in the epiphyseal area prior to ossification. The epiphyses of the upper and lower femur, upper tibia and upper humerus are most often involved.

Typically, resorption or incorporation into the epiphysis occurs in the first year of life. The orderly regression of the changes seen in this patient has not been previously reported. Growth disturbances of the involved areas are the rule.

The disease is more frequently seen in girls and the etiology is unknown. Prognosis for life seems favorable.—*Barry E. Gerald*, M.D.

Werne, Sven. Compression fracture of the femoral head in association with cortisone therapy. *Acta orthop. scandinav.*, 1962, 32, 413–420. (From: Orthopaedic Clinic, Institute for Cripples, Hälsingborg, Sweden.)

Two patients with spontaneous compression fractures of the femoral head associated with prolonged cortisone therapy are reported.

In 1 patient receiving cortisone for pemphigus, a fracture was found 1 year after the initiation of drug therapy. The second patient, being treated for polyarthritis, had received cortisone intermittently for 8 years and intensively for 3 years before symptoms directed attention to the hip where a similar fracture was found. Neither patient had any history of recent trauma and both had been ambulatory prior to the fracture. After bed rest over a period of 2 years, 1 patient had decreased pain.

The crown of the femoral head was compressed in both cases, resembling aseptic necrosis after a fracture of the femoral neck. The greater blood supply of the femoral head, in comparison with the neck, is thought to produce a greater degree of osteoporosis in the femoral head, resulting in the compression fracture.—Barry E. Gerald, M.D.

COLONNA, PAUL C. The utilization of movement in joint roentgenograms. *Acta orthop. scandinav.*, 1962, 32, 247–251. (From: University of Pennsylvania, Philadelphia, Pa.)

The author emphasizes the sites in orthopedics where roentgenographic studies of function are important. These studies may demonstrate excessive mobility, due to recurrent dislocations or ligamentous tears.

Lateral erect and supine roentgenograms of the lumbar spine may show an increased lumbosacral angle. Bending roentgenograms in scoliotic patients are used to determine the progression of the curve. After fusion, studies made in flexion and extension, as well as bending, can help to evaluate the integrity of the fusion. Roentgenograms of the symphysis pubis, made with the body weight first on one foot then on the other often show movement in patients with sacroiliac dislocation. Roentgenograms with the "push-pull" technique aid in evaluation of delayed union of femoral neck fractures.

This concept is of particular aid in congenital bone and joint disturbances. It is used to demonstrate the degree of anteversion of the femoral head and neck in congenital dislocation of the hip. The "push-pull" technique in this disease is well known. Forefoot and hindfoot varus, as well as equinus, can be well demonstrated.—Barry E. Gerald, M.D.

STANKLER, LESLIE. Posterior dislocation of the clavicle: a report of 2 cases. *Brit. J. Surg.*, Sept., 1962, 50, 164–168. (From: Victoria Infirmary, Glasgow, Scotland.)

Posterior dislocation of the clavicle is a very rare condition.

In this article 2 cases are described in which the diagnosis was initially missed, one for  $4\frac{1}{2}$  years and the other for 1 month following injury. Both patients were young, well developed males who sustained shoulder injuries during sporting activities. Neither had definitive treatment. One patient was symptom free  $2\frac{1}{2}$  years after injury, apart from cramp and cyanosis of the hand and venous distention of the forearm following excessive use of the right arm. The other developed complete obstruction of the left subclavian vein which resolved on administration of anticoagulants.

The complications of posterior dislocation of the clavicle include death due to laceration of the trachea or hemothorax, compression of the trachea, and pressure on the esophagus or subclavian vein.

Roentgenologic examination is essential. Paterson has reported that the sternoclavicular joint made an angle of 20°-25° with the sagittal plane in 2 of his 3 cases of posterior dislocation, while an angle of 0-5° was noted in the control series. Laminagraphy establishes the diagnosis beyond doubt.—Francis P. Shea, M.D.

Pan, P., and MacKinnon, W. B. "Benign" giant cell tumour of thoracic vertebra with pulmonary metastasis. *Canad. M. A. J.*, Nov., 1962, 87, 1026–1029. (From: Department of Pathology, St. Boniface General Hospital, St. Boniface, Manitoba, Canada.)

The malignant potential of giant cell tumors cannot be accurately predicted from their histologic appearance. Giant cell tumors of bone become frankly malignant in 10 per cent of cases and these tend to be locally destructive, rapidly growing and likely to metastasize. Dahlin has reported 11 cases of malignant giant cell tumors, 9 of which were previously treated as typical, benign giant cell tumors. These slides were carefully reviewed and no hint of their malignant potential was discerned from their appearance.

The case of a 46 year old woman is reported who had a giant cell tumor of T-10 which was excised, curetted and packed with bone chips. The histologic sections showed no characteristics of malignancy. Three years later a solitary lung nodule was detected

and laminagrams revealed no evidence of calcium. The nodule was excised and had the same histologic appearance as the original giant cell tumor. Roentgenograms of the spine at that time revealed no evidence of interval change. She has remained well I year after thoracotomy.—David Morse, M.D.

COLLARD, M. Contribution à l'étude de l'ostéogénèse imparfaite létale et de l'ostéopsathyrose. (Contribution to the study of lethal osteogenesis imperfecta and osteopsathyrosis.) J. belge de radiol., 1962, 45, 541–580. (From: Service de Radiodiagnostic de l'Hôpital de Bavière, Université de Liège, Belgium.)

Classically, certain syndromes of osseous fragility have been called osteogenesis imperfecta when occurring in the fetus or infant (Vrolik's disease), and osteopsathyrosis (osteogenesis imperfecta tarda or Lobstein's disease) when found in the adult. Some observers have classified separately the triad of Van der Hoeve (blue sclera, osseous fragility, and deafness). In his exhaustive study the author has drawn on his experience in 11 cases and concluded that osteopsathyrosis and the triad are indistinguishable. Notably, adult victims of osteopsathyrosis who did not report deafness actually had audiometric changes.

Five of the author's cases with blue sclera had measured normal scleral thickness; therefore, the blueness need not be due to thinness only, but must involve a qualitative difference.

Noting that osteopsathyrosis can be transmitted either by a mendelian dominant or a recessive trait, the investigator was able to determine that in one of the families studied the trait was dominant; in other cases he suspected a mutation based on consanguinity.

Microradiographs demonstrate that in normal bone the cortex is thick, and the trabeculae through the spongiosa exhibit a certain regularity and relation to lines of force. In senile osteoporosis the trabeculae become fewer, but those remaining are relatively dense, thick, and still preserve some homogeneity. However, in osteopsathyrosis not only is the cortex thin but the trabeculae are usually slender and with less pattern.

Osseous fragility roentgenologically is characterized not only by osteoporosis, deformities, cysts and gross fractures, but also by microfractures: these look like those transverse lines which so frequently parallel metaphyses of long bones and represent rest periods of endochondrial ossification. The microfractures differ from these normal lines only in direction.

Contrary to the findings of other investigators, the author reports that defects of the teeth are practically the rule in osteopsathyrosis; these consist of dental deformities, caries, anarchic deposits of calcium and disturbances of odontogenesis.—Frank A. Riebel, M.D.

Gorlin, Robert J., and Psaume, Jean. Orodigitofacial dysostosis—a new syndrome; a study of 22 cases. J. Pediat., Oct., 1962, 61, 520–530. (From: Division of Oral Pathology, School of Dentistry, University of Minnesota, Minneapolis 14, Minn.)

The authors present a study of 22 cases, 10 new and 12 previously published, of a new syndrome, occurring in patients with cleft palate and seen so far only in females. The incidence to date is reported to be I per cent of all patients with cleft palate.

Orofacial dysostosis consists of several features which are rather constant: (1) occurrence in the female sex; (2) numerous hyperplastic frenula in the upper and lower vestibular sulci that cleft the alveolar processes; (3) cleft of the tongue into 2, 3, or 4 lobes; (4) clefts or defects of the hard and soft palate; (5) pseudocleft of the median portion of the upper lip; (6) anomalies of the hand which include digital osteoporosis, brachydactyly, camptodactyly, syndactyly, and, rarely, polydactyly; (7) dental anomalies that include absence of lower lateral incisors, supernumerary cuspids or bicuspids, impaction of cuspids, etc.; and (8) flatness of the nasion-sella-basion angle.

Less commonly there may be: (9) hypoplastic changes in the nasal alar cartilages; (10) mental retardation; (11) trembling; (12) porencephalic cyst or subdural hygroma; (13) alopecia and/or dryness of the scalp, seborrheic changes in the facial skin; (14) hypoplasia of the malar bones; (15) mucous membrane fistulas of the lower lip; and (16) dystopia canthorum and epicanthus.

Roentgenographic findings include: (1) nasion-sella-basion angle increased significantly over 131 degrees, usually about 144 degrees; (2) short, thick tubular bones with irregular reticular areas of radiolucency extending through the entire shaft, especially in the hands and feet; (3) basal lordosis; and (4) steep anterior fossa due to elevation of the cribriform plate and lesser wings of the sphenoid.— Sam B. Baker, M.D.

Morel, Robert, Weber, André, and Dela-Haye, Roland-Paul. (Paris-Versailles, France.) Les aspects radiologiques des atteintes articulaires du syndrome de Fiessinger-Leroy-Reiter. (Radiological aspects of articular lesion of the Fiessinger-Leroy-Reiter Syndrome.) J. de radiol., d'électrol. et de méd. nucléaire, June-July, 1962, 43, 383-396.

This syndrome is characterized by conjunctivitis, urethritis, and articular involvement, often following an episode of enteritis, which is frequently epidemic.

Articular manifestations during epidemics of infectious colitis have long been known. During World War I Fiessinger and Leroy described them in the

conjunctivo-urethro-synovial syndrome that had occurred in 4 patients during a pseudogonorrheal epidemic of dystentery which was bacillary and amebic at the same time. A month later, Reiter reported a similar finding in a case with the demonstration of a spirochete that has never been observed since. During World War II, numerous observations in all armies were recorded. In 1949, a relationship between this syndrome and ankylosing spondylarthrosis was stressed repeatedly in the literature.

The present study is based on 40 cases observed between 1955 and 1961 among repatriates from North Africa, a total of 83 articular localizations.

According to many authors, this syndrome occurs in 80 per cent of cases following a colitic episode without any bacteriologic specificity and which is often not serious. In 18 per cent of cases, it follows a genitourinary episode (urethritis without bacteria or caused by *Gonococcus* or unimportant germs such as *Bacillus coli*, *Enterococcus* or *Proteus*). Coprologic and serodiagnostic studies are often negative. An ultragerm (L form) seems to be the cause.

The graphic distribution of the syndrome of viral hepatitis and poliomyelitis is virtually identical. The factors favorable to epidemiology include poor hygiene, promiscuity, and fatigue of soldiers in the field. In North Africa the disease reappeared every year with a maximum incidence in the summer and fall. Male patients were involved in 90 per cent of the cases.

Clinically, diarrhea, conjunctivitis, urethritis, and arthritis are the 4 main manifestations which succeed each other in 70 to 80 per cent of cases, but this sequence may be altered or reversed. The acute colitic episode lasts between 3 and 8 days. About 10 days later, urethritis appears. Ocular involvement occurs after diarrhea, often with urethritis, and slightly prior to articular symptoms. Articular manifestations are an essential element of the syndrome, and in order of predilection are localized in the lower limbs in 70 per cent of the cases and in the knee in 35 to 50 per cent. They are seen in decreasing frequency in the ankle, foot, wrist and hand, then elbow, hip, and shoulder. Arthralgia may or may not be followed by arthritis but if so, will suddenly appear in the joint.

Roentgenologic changes may be observed in the soft tissues and bone structures. During the phase of evolution, densification and thickening of periarticular tissues (ligaments, muscular tendons, and muscles) may be noted; these are caused by synovial hypertrophy and hydrarthrosis. Extra-articular structures (ligaments, tendons, and serous tissue) may also be involved, even when located far from an articulation. At the phase of sequelae, calcification takes place in the capsule, muscular tendons or osseous ligaments; this may be granular or lamellar. The osseous manifestations consist in demineralization and bony island formations in the spongiosa of the epiphyseo-metaphyseal area. Anomalies of the

osseous contours appear as cortical erosions or effractions, spurs, osteophytes, or hyperostosis. By the end of the first year, many patients are showing signs of ankylosing spondylarthritis.—H. P. Lévesque, M.D.

REYNOLDS, JACK. An evaluation of some roentgenographic signs in sickle cell anemia and its variants. *South M. J.*, Nov. 1962, 55, 1123–1128. (From: Department of Radiology, The University of Texas Southwestern Medical School and Parkland Memorial Hospital, Dallas, Tex.)

Roentgen signs are usually absent in sickle cell trait, but are found in sickle cell hemoglobin C disease and are common in the true sickle cell anemia. The roentgenographic signs are due to either compensatory hyperplasia of erythropoietic elements in response to the anemia or bone rarefaction secondary to infarction with sclerosis appearing as healing progresses.

Although frequently overlooked, the mandible is the site of characteristic bone changes and is an area that can be readily examined for bone detail. Increased radiolucency results from expansion of the marrow elements. The cortex of the inferior margin thins to 4 mm. or less. Coarse, sharply defined linear trabeculae appear as the finer ones are lost. The lamina dura also appears more prominent. This radiolucency of the mandible is not pathognomonic of sickle cell anemia as it can occur in other anemias and occasionally the normal patient. A rounded area of increased density may appear which probably represented the site of a healed bone infarct. This can be differentiated from alveolar abscess because it is more sharply marginated and bears no relationship to periodontal structures. The mandibular changes are present in about 80 per cent of cases as opposed to the spine which is roentgenographically involved in 35 to 70 per cent of cases.

The "hair on end" pattern seen in the skull is only present in about 5 per cent of cases. Also seen are thickening of the calvarium, a granular appearance and marked thinning of the tables of the calvarium with associated widening of the diploic space.— David Morse, M.D.

GIUNTOLI, L., and GUARESCHI, B. II problema medico-legale della spondilolistesi nel quadro radiologico. (The medico-legal problem of spondylolisthesis in its roentgenological aspects.) *Radiol. med.*, Sept., 1962, 48, 833–860. (Address: Dr. L. Giuntoli, Via Fontana 14, Milano, Italy.)

Spondylolisthesis is the term that Killian applied in 1892 to an anterior gliding of a vertebra, secondary to a lysis or an elongation of its isthmus. Since that time much has been written about this condition and the term itself has been subject to discussion.

The term derives from two Greek words (spondylos and olisthesis), which mean a gliding of a vertebra, not only anteriorly, but also posteriorly or laterally. For this reason, the authors suggest the term for any vertebral displacement. Posterior olisthesis consists in a posterior displacement of a vertebra and the vertebrae above it over the vertebral body immediately below; lateral olisthesis consists in a lateral displacement of a vertebra; anterior olisthesis, the most frequent, consists in a progressive anterior displacement of a vertebra and the vertebrae above it in relation to the vertebral bodies below. In this latter group are included: (1) the cases of spondylolisthesis as generally accepted; (2) the cases of pseudospondylolisthesis as described by Junghanns; (3) the vertebral dislocation or subdislocation secondary to a rupture of the intervertebral disk associated often with a fracture of the posterior arch; and (4) the slipping of a vertebra secondary to an inflammatory or neoplastic process involving the arch and the

A variety of theories have been advanced to explain the etiology of this condition. The authors are of the opinion that the hypothesis advanced by Boucher is the most satisfactory and convincing. Boucher suggested that spondylolisthesis is secondary to a dysplasia of the posterior vertebral arch, and not necessarily of the isthmus only, related to the orthostatic position of the human body and of hereditary nature.

The roentgen findings of the various types of olisthesis are described. To measure the degree of slipping of a vertebra, the methods devised by Taillard and Junghanns are found to be the most reliable.

In discussing the medico-legal implications of olisthesis, the authors are of the opinion that: (1) severe and acute trauma cannot produce olisthesis; (2) even if a known spondylolysis is present in an individual, acute and severe trauma will not result in secondary olisthesis; (3) it is possible on the basis of the roentgen findings to determine whether olisthesis is of a recent onset or of long standing; and (4) undoubtedly, trauma in a patient with vertebral olisthesis often produces symptomatology characterized by pain and limitations of movements, which might last for quite a long time.—A. F. Govoni, M.D.

#### BLOOD AND LYMPH SYSTEM

Barbaccia, F. Sulla opacizzazione delle vene della coscia in corso di arteriografia femorale: osservazioni radiologiche in tema di comunicazioni artero-venose. (Opacification of the veins of the thigh in the course of femoral arteriography: radiologic study of arteriovenous communications.) *Radiol. med.*, Nov., 1962, 48, 1073–1098. (Address: Via Mac Mahon 79, Milano, Italy.)

The syndrome of insufficient peripheral arterial supply has been considered for many years to be principally the consequence of obstructive disease of the arterial lumen or more rarely the result of an arteriovenous fistula either acquired or congenital. More recently another possible cause of inadequate peripheral arterial flow has been brought to light, *i.e.*, the abnormal precapillary arteriovenous connections, that is to say, preformed arteriovenous anastomoses which have been demonstrated anatomically by certain authors.

The dilatation of these direct arteriovenous communications may determine partial or total exclusion of the capillary circulation. In normal individuals as well as in those affected by vascular pathology, short circuits of the arteriovenous circulation have been demonstrated angiographically.

An early visualization of the veins of the thigh during arteriography because of the dilatation of arteriovenous communications has been obtained in patients not affected by vascular disease. In a high percentage of patients undergoing arteriography because of obstruction of the superficial femoral artery, the author has observed rapid and massive opacification of the veins. The short circuit produced by the dilatation of the arteriovenous anastomosis aggravates the diminished peripheral flow.

In conclusion, the author maintains that the course and origin of circulatory alterations of the inferior extremity in some instances may be related to the system of arteriovenous connections.—

Anthony A. Blasi, M.D.

Doroshow, Louis W., Yoon, Ha Young, and Robbins, Martin A. Intrathecal injection, an unusual complication of translumbar aortography: case report. J. Urol., Sept., 1962, 88, 438–439. (From: Department of Urology, Sinai Hospital, Baltimore, Md.)

The authors report a case of considerable interest and importance to those who are performing translumbar aortography and renal arteriography.

A 31 year old female patient presented with pain in the left flank increasing in severity. Studies showed loss of function with an enlarged left kidney and a normal right kidney and ureter. Attempts at retrograde pyelography were unsuccessful because of obstruction of the intramural segment of the left ureter. A No. 17 spinal needle was inserted for translumbar aortography under general anesthesia. Clear watery fluid was obtained and in the belief that the needle was in a hydronephrotic sac, 7 cc. of 50 per cent hypaque was injected in an effort to obtain an antegrade pyelogram. The resulting roentgenogram showed that an intrathecal injection had been made. Subsequently, the needle was placed in the aorta and following injection of contrast medium the left renal artery was not visualized. As the effect of general anesthesia wore off, the patient began to have myoclonic contractions of the lower limbs gradually ascending until she died approximately 2 hours later. Postmortem examination revealed tuberculosis of the left kidney with extensive caseous necrosis.

It is concluded that intrathecal injections of hypaque and similar radiopaque drugs are extremely irritating in the subarachnoid space. They should not be injected for aortography unless the operator is certain that the end of the needle is in the aorta. Some of the newer radiopaque contrast media are reported to have a less toxic effect on the blood supply of the lower spinal cord and nerve roots, but meticulous attention to the technique of aortography is of primary importance.—George W. Chamberlin, M.D.

STEINBERG, ISRAEL, and EVANS, JOHN A. Conray: a new cardiovascular and urographic contrast medium. *Radiology*, Sept., 1962, 79, 395–400. (From: The Department of Radiology, The New York Hospital-Cornell Medical Center, New York, N. Y.)

The authors report a clinical trial of a new low viscosity, highly water soluble organic iodide contrast agent, conray, in a series of over 300 patients.

The free acid of conray is iothalamic acid which contains 62 per cent iodine. Conray is available in two forms: a 60 per cent solution of the N-methylglucamine salt, containing 28 per cent iodine, and an 80 per cent sodium salt solution, containing 48 per cent iodine. The authors used the 60 per cent compound for intravenous urinary tract studies, and percutaneous arterial puncture for peripheral vascular and carotid-vertebral angiography. The 80 per cent solution was used for intravenous angiocardiography, nephrotomography, intravenous abdominal aortography and peripheral arteriography, and retrograde abdominal arteriography. The low viscosity of the contrast medium permitted rapid hand injection. The intravenous injection of the 60 per cent conray solution for urography was practically free of undesirable reactions, producing usually only mild and transient heat. Conray, 80 per cent, injected rapidly intravenously for angiocardiography and nephrotomography, produced moderate to intense heat, flushing and transient headache. Three severe reactions occurred: the precipitation of asthmatic attacks in 2 patients, and a severe thrombophlebitis in 1. In an addendum, 3 severe cardiorespiratory reactions are described in 115 additional patients having angiographic studies with 80 per cent conray since this paper was submitted.

Urographic studies made after the intravenous injection of 30 ml. of 60 per cent conray, and the cerebral and peripheral arteriograms made after injection of small quantities of the same solution, were equivalent in radiopacity to those following injections

of other dilute contrast agents such as urokon 30 per cent and hypaque 50 per cent. The radiopacity of 80 per cent conray, containing 48 per cent organic bound iodine, was equal to urokon 70 per cent and hypaque 90 per cent, each of which contains 46 per cent iodine, and was superior to ditriokon (40 per cent iodine).

The authors conclude that 80 per cent conray appears to be a highly satisfactory cardiovascular contrast agent, but search must continue for the ideal compound, one without toxicity, of low viscosity and high radiopacity.—Ralph Bowman, M.D.

Rösch, J., and Bret, J. Unsere Erfahrungen mit der Milzarteriographie in der Diagnostik der Milzerkrankungen. (Our experiences with splenic arteriography in the diagnosis of diseases of the spleen.) Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin, Sept., 1962, 97, 239–255. (Address: Dr. J. Rösch, V. Borcove 2, Brevnov, Praha 6, Czechoslovakia.)

The catheter is inserted through a puncture in the femoral artery, using a Seldinger needle. The catheter is advanced in retrograde fashion—under fluoroscopic control—until it reaches the level of L-1, where it usually enters the celiac artery. During the advance it is advisable to inject several times through the catheter a solution of heparin in normal saline for the prevention of thrombosis. Sometimes it is possible to insert the catheter directly into the splenic artery. After preliminary injection of a test dose, 20–30 cc. of 70 per cent iodinated contrast medium is injected. For upper aortography, the catheter is advanced to the height of T-12 and 40 cc. is injected.

Sixty-four splenic arteriographies were performed in 60 patients, ages 17 to 77 (average 43) years. As controls 20 patients were used with kidney ailments, whose spleen was well visualized in high aortographies. There were no serious reactions; the only complication was local hematoma at the site of puncture, which occasionally could not be stopped by pressure.

The spleen was displaced in 2 patients, 1 with ascites, the other with left kidney tumor. Three females (ages 34, 57, and 77 years) had aneurysms of the splenic artery. Twenty-one patients (ages 21–58 years) with chronic hepatitis were examined; only 10 of them had definite splenic enlargement and only 4 had visible parenchymal destruction (peripheral rarefaction) in the spleen. Among 14 patients with advanced cirrhosis of the liver, 12 had pronounced splenomegaly, usually with poor intrasplenic vascularization. Other instances are also reported in the article.—*E. R. N. Grigg, M.D.* 

Bovy, P. Spléno-portographies dans le cancer primitif du foie. (Spleno-portography in primary cancer of the liver.) J. belge de

radiol., 1962, 45, 406–420. (Address: 26 Jadotville, Katanga, Congo.)

Primary carcinoma of the liver is often found among the native Africans in intertropical Africa.

Among the data observed the following are significant: (1) Primary liver carcinoma, especially malignant hepatoma, very frequently develops in a cirrhotic liver; (2) the incidence in the male is higher than in the female; and (3) it may be seen at all ages, but is most common in the third and fourth decades of life.

Primary carcinoma of the liver may occur in one of the following forms:

- (1) Massive carcinoma without cirrhosis. This is usually a large, single, well-circumscribed tumor involving chiefly the right lobe. Metastasis may develop to the left lobe.
- (2) Nodular carcinoma. This is invariably associated with cirrhosis of the liver. The liver is voluminous in size, irregular and studded with nodules of different sizes. This is the most frequent type.
- (3) Diffuse or micronodular carcinoma. This differs from the preceding two types by the fact that the liver is rarely if ever enlarged. The appearance may be that of a miliary carcinomatosis, diffusely spread throughout the liver, or that of replacement of the hepatic parenchyma by cords or nodules involving all liver lobes.

A series of 8 cases were examined by means of splenoportography, followed by gross anatomic and histologic studies.

The roentgen findings, briefly summarized, consist of compression, displacement and obstruction of the portal intrahepatic veins as well as amputation and thrombosis of the extrahepatic portal veins.

The differential diagnosis between primary carcinoma of the liver, metastatic carcinoma, cirrhosis and inflammatory diseases is discussed.

Two tables and reproductions of 23 roentgenograms accompany this article.—William H. Shehadi, M.D.

VIAMONTE, MANUEL, JR., and PARKS, RAYMOND E. Linfografía (Linfangio-Adenografía). (Lymphography [lymphangio-adenography].) Radiol. Interamericana, June, 1962, 1, 25–29. (Address: Department of Radiology, Jackson Memorial Hospital, Miami, Fla.)

The authors report their experience in more than 80 patients who were studied by lymphography. The technique consists in first visualizing the lymph channels of the dorsum of the foot, hands, or penis with 1.5 cc. of a 1 per cent water solution of Patent Blue Violet injected intradermically. The lymph ducts stand out in blue and can be dissected and cannulated with a 27 or 30 gauge needle, through which 12 cc. of ethiodol is injected, at a rate of 0.2

cc. per minute. After the injection has been completed, roentgenograms are taken of the areas of lymph drainage: extremities, pelvis, abdomen, and thorax. Better detail of lymph node structure is, however, obtained by taking subsequent roentgenograms at 24 and 48 hours. Because the lymph nodes remain opacified for several weeks and months, the same areas may be rechecked at later times. As for complications, one occasionally observes delayed healing of the operative wound; at times, a miliary infiltrate in the lungs, representing the deposit of contrast medium in the pulmonary interstitial tissue, appears which has no clinical significance. Careful technique is required to avoid fat embolism.

The roentgenographic appearance of the lymph nodes often gives a clue to the diagnosis, and helps in evaluating the status of a patient suffering from lymphadenitis, metastatic malignancies, lymphomas, and lymphedema. It is a good test in determining the thoroughness of a lymph node dissection, and, among other applications, it serves to appraise the result of therapy in a number of conditions involving lymph nodes.—F. Comas, M.D.

#### GENERAL

Holmes, Brian R., and Wright, D. J. Image orthicon fluoroscopy of a 12-inch field and direct recording of the monitor image. *Radiology*, Nov., 1962, 79, 740–751. (From: Toronto General Hospital, Toronto 2, Ontario, Canada.)

The authors present a clear and practical discussion of the Marconi image orthicon system and to the interested reader the original article is recommended in its entirety. In this system, roentgen rays striking a 12 inch diameter fluorescent screen produce light photons which are focussed by a mirror optical system to a special  $4\frac{1}{2}$  inch image orthicon. The viewing image covers a 12 inch diameter over the central flat portion of a 17 inch television monitor. With additional monitors the image can be recorded on standard cine film, roll film, or cut film. The system differs from others in that it achieves amplification with only the mirror optics plus the orthicon, omitting a fixed gain image tube, and that it is possible to vary the gain in the orthicon. The amplifier system components are as follows: (1) roentgen ray tube (0.3 mm. focal spot); (2) 12 inch flat fluorescent screen; (3) mirror optical system; (4) image orthicon and associated electronic amplifiers; (5) viewing and recording monitors; and (6) cameras.

Roentgen rays are produced by a 0.3 mm. focal spot and, because of this factor, the target to table top distance need not be greater than 18 inches. The fluorescent screen covers a field of 11×11 inches and allows a relatively large field of view. Also, since photo-emission from fluorescent screens is de-

pendent on the composition, the system attempts to obtain the maximum photon gain by use of Sb-Cs(O). The screen is thin and fine grained and since the screen is flat, some of the distortion inherent with amplifiers is avoided. The screen image is transmitted to the image section of the orthicon by the mirror optical system which allows the final image plane to be matched with the shape of the orthicon photocathode, further reducing aberrations. Because of the optics, a magnification factor of  $\frac{1}{4}$  is produced so that the maximum image size on the screen is reduced to approximately 3.2 inches in diameter for presentation to the orthicon.

The image orthicon has 3 stages: the image section, the scanning section, and the multiplier section. The image section of the tube converts a pattern of visible light into a pattern of electron charges. Light which has originated from the fluorescent screen is focussed on the photocathode of the orthicon where photoelectrons are emitted. These in turn are focussed on a target, being accelerated by a potential difference, while exact correlation between points on the cathode and target is maintained. Secondary electrons, ejected from the target, are attracted to an adjacent mesh, leaving the target with a positive charge pattern. In the scanning section, a focussed beam of electrons from the electron gun, is constrained to approach the rear surface of the target before returning on a path parallel to the initial path of the beam. The returning beam is modulated according to the arrangement of charges on the target and, with appropriate deflection coils, a scanning pattern is achieved. The returning beam is fed into a multiplier section of 5 dynodes, which boosts the signal strength. Sensitivity adjustments are possible varying from high patient dose and low amplification to low patient dose and high amplification. Also, by appropriate controls, pulsing, image magnification, image reversal, and image inversion can be achieved.

The signals from the orthicon are amplified and applied to one or more 17 inch monitors. For cine recording, one monitor is coupled directly to the cine camera by means of a hood, and frame speed is altered by simple gear change. A roll film or cut film device can be coupled to another recording monitor. A brief discussion of patient dosage is given.

This system presents many novel features including appropriate improvement of image quality during a recording sequence. A major advantage is that every one in the room sees the high quality picture at the moment it is being recorded on film. In an addendum the authors state that an Ampex videotape recorder has subsequently been used with the above system with excellent results. The obvious advantages to this additional component were: immediate playback, higher resolution, and optimum electronic contrast enhancement, both for immediate interpretation and subsequent kinescopic recording. —Edward B. Best, M.D.

GIRDANY, BERTRAM R., and GAITHER, EDWIN S. Televex-tape-kinescopy and cineradiography. *Radiology*, Nov., 1962, 79, 752–754. (From: Department of Radiology, Children's Hospital of Pittsburgh, Pittsburgh 13, Pa.)

Additional experience since their original report has convinced the authors that television tape is a proved method of routine recording of the fluoroscopic image. In their study they use fluoroscopes equipped with Televex image orthicon television cameras optically coupled to Philips 9 inch image amplifiers. The fluoroscopic examinations are recorded simultaneously on television tape without loss of picture quality or detail, and at the same low levels of radiation required for closed circuit television viewing alone.

The combination of television tape recorder and Televex has been in regular use at the Children's Hospital of Pittsburgh since November, 1960. All fluoroscopic examinations are recorded on television tape and are transferred to 16 mm. movie film via the kinescopic recorder. The 16 mm. film is processed in an automatic developer and is available for projection on a 16 mm. projector. Selective angiography is used with simultaneous recording directly on 16 mm. film and on television tape. If the cine film is technically satisfactory, the taped examination is erased. If it is not satisfactory, the taped examination is transferred to film via the kinescopic recorder. The authors fluoroscope and record at ma. settings from 0.04 to 0.2 and at kilovoltages from 50 to 120. The r per minute output measured at the table top without back scatter varies from 0.02 to 0.2 according to the fluoroscopic factors used. Prolonged fluoroscopic examinations are therefore safe and feasible. In using television tape the radiologist views what he is recording; the recording is as satisfactory as the picture on the television monitor. He can review all or any part of the examination as often as necessary.

Currently television tape recorders are relatively expensive and the installation described by the authors utilizes a television engineer on a full time basis. It is hoped that enough problems will be solved to allow other installations to operate without such skilled workmen.

The major advantages of this system lie in low radiation levels for recording and in the availability of immediate playback.—*Arno W. Sommer, M.D.* 

HILBISH, THEODORE F., and MOREL, JOSEPH M. Problems associated with installation, operation, and maintenance of image orthicon radiographic equipment. *Radiology*, Nov., 1962, 79, 755–759. (Address: 5675 Hardy Avenue, San Diego 15, Calif.)

The installation, operation and maintenance of orthicon and vidicon systems brings the radiologist into close contact with the field of electronics. Prob-

lems associated with such a project are discussed in detail.

The intended use of the equipment to some extent governs the type of apparatus. The image orthicon pickup system provides more gain in light intensity and less persistence of the image than the vidicon. However, the orthicon system is more expensive and requires more frequent and costly maintenance services. Therefore the vidicon system may be the unit of choice for chest studies; the orthicon system seems preferable if thick parts of the body are to be examined

The ceiling may need to be reinforced to support the additional weight of the intensifying tube and the image orthicon. New electrical circuits may be required in the x-ray room to provide a power source of 125 amperes. Image tube size will depend upon intended utilizations. The authors selected a 22 cm. tube to permit coverage of a reasonably large patient area. The sync generator provided with the image orthicon unit may be used or it may be more desirable to use a central sync generating system.

Thirty or 40 minutes is required to "warm up" the unit for fluoroscopic operation. Functional failure can usually be traced to one of four sources: (a) a fuse has blown; (b) a vacuum tube has burned out in the TV chassis; (c) the fluoroscopic screen has been left in front of the image tube; and (d) the fluoroscopist has brushed against the beam, gain or focus dials on the side of the image tube. A 3.5:1 ratio grid below the image intensifying tube was found to be more satisfactory than an 8:1 stationary grid. A fixed focusing ring for the 11 mm. camera and a change in the beam splitting mirror were required for satisfactory cineradiography.

The roentgen exposure of the patients was greater than had been anticipated. Normally, fluoroscopy of adults is performed at 1 to 2 ma. and 80 to 95 kv. This results in an exposure level of 2 to 3 r per minute at the table top. For heavy patients as much as 4 ma. and 125 kv. peak may be required to produce a good television image.

The authors would not consider returning to conventional fluoroscopic methods. Improvements have been made since the equipment was installed and further rapid improvements in image orthicon and vidicon systems, at lower price levels, are predicted.—Arno W. Sommer, M.D.

## RADIATION THERAPY

Santagada, A. Il trattamento roentgen del timo, secondo la tecnica di Bollini, nella myasthenia gravis pseudoparalytica: risultati clinici su 19 casi. (Roentgen therapy of the thymus, according to Bollini's technique, in pseudoparalytic myasthenia gravis: clinical results in 19 cases.) Radiol. med., Oct., 1962, 48, 996–1010. (Address: Via Oberdan 4, Bologna, Italy.)

As is known pseudoparalytic myasthenia gravis is characterized by the rapid exhaustion of voluntary muscles which under the action of fatigue temporarily lose their power to contract.

With the exception of some cases which present an acute course with involvement of the respiratory muscles and in which death may ensue in a few days, the disease is chronic and progressive with periods of remission.

The results of thymectomy and of roentgen therapy tend to confirm experimentally the hyper-

thymic genesis of myasthenia.

The abolition of thymic activity either by surgical resection of the thymus or by its ablation by irradiation represents a true causal therapy. The administration of prostigmine with the intent of restoring myoneural function controls the muscular disturbance and is of importance in asphyxia and syncope. But it is only palliative and symptomatic.

The author reports 19 cases of myasthenia gravis treated according to Bollini's technique. The thymic region is irradiated through 3 fields, 1 sternal and 2 scapulovertebral directed so as to converge along the median line at the level of the sternum. A dose of 200 r is delivered to each field daily for a total dose of 1,800 r per field. The cycle is repeated after 3 to 5 months. The number of cycles which produced the best results was three.

Of the 19 cases thus treated, 16 have recovered and 3 are dead.—Anthony A. Blasi, M.D.

Sweeney, William J., III, and Douglas, R. Gordon. Treatment of carcinoma of the cervix with combined radiation and extensive surgery. Am. J. Obst. & Gynec., Oct., 1962, 84, 981–991. (From: The Department of Obstetrics and Gynecology, Cornell University Medical College, the Lying-In Hospital of the City of New York, and the Woman's Clinic of the New York Hospital, New York, N. Y.)

As part of a clinical research program beginning in 1948, 102 selected patients with carcinoma of the cervix were treated with combined irradiation and surgery at the Woman's Clinic of the New York Hospital.

Those selected were in good physical condition, of a relatively young age and with clinically early disease. Six weeks after definitive radiation therapy, hysterectomy and pelvic lymphadenectomy (85 cases) or cervical stump excision and pelvic lymph node dissection (17 cases) were performed. Clinical staging prior to therapy was Stage I, 39 cases; Stage II, 54 cases; Stage III, 9 cases.

There was no residual carcinoma and no lymph node involvement in the surgical specimens of 60 cases (58.8 per cent). There was residual carcinoma in 25 cases; residual carcinoma plus positive lymph nodes in 12 cases; and no residual carcinoma but

positive lymph nodes in 5 cases. It is pointed out that less residual disease might have been present had the surgery been delayed a longer period after irradiation.

The 5 year survival for Stage I was 82 per cent; Stage II 66.7 per cent; and Stage III 22 per cent. The 5 year survival for those with involved lymph nodes was 35.8 per cent. Positive lymph nodes were found in all clinical stages.

The operative mortality was 2.9 per cent. Fistulas

were present in 15 per cent.

The authors conclude that they may have improved the 5 year survival, especially among those with involved lymph nodes, but that the series is too small to be certain. They feel justified in continuing the study.—H. J. Klos, M.D.

DICK, DONALD A. L. Carcinoma of the bladder treated by external irradiation. *Brit. J. Urol.*, Sept., 1962, 34, 340–350. (From: The Cancer Clinic, Edmonton, Alberta, Canada.)

On the basis of his treatment of 122 cases of carcinoma of the bladder, the author concludes that the degree of tumor invasion correlates more closely with radiosensitivity than with histologic grade. He further concludes that, because of the tendency of transitional carcinoma to recur, the entire bladder should be irradiated in superficial carcinoma. However, because of the higher morbidity in the irradiation of more invasive lesions, these latter should be accurately localized and only the lesions themselves should be intensively treated.

All of the reported cases had previous surgery, usually multiple fulgurations. Most patients had the whole bladder irradiated through one anterior and two posterior portals. Most received a tumor dose of from 6,000 to 6,250 rads in 5 weeks with either telecobalt (105 cases) or 250 kv. roentgen rays (17 cases). If the lesion was far advanced or the patient's condition poor, lesser doses were delivered.

The patients whose lesions were limited to the mucosa and submucosa had a 5 year survival of 73 per cent and a recurrence-free 5 year survival of 53 per cent. Those patients whose lesions invaded the muscle wall of the bladder had a 5 year survival of 46 per cent, 39 per cent recurrence-free. If the lesion invaded the perivesical fat, there was no 5 year survival.

Complications of radiation therapy included contraction of the bladder, 9 cases; mucosal slough over 6 months, 2 cases; hemorrhage due to telangiectases, 4 cases; stricture of the urethra, 5 cases; and subcutaneous fibrosis, "a few."

Morbidity can be lessened by control of urinary tract infections.—H. J. Klos, M.D.

VAETH, JEROME M., LEVITT, SEYMOUR H., JONES, MALCOLM D., and HOLTFRETER, CHARLES. Effects of radiation therapy in survivors of Wilms's tumor. *Radiology*, Oct.,

1962, 79, 560–568. (From: Department of Radiology, University of California School of Medicine, San Francisco, Calif.)

A study on a group of 12 patients surviving 5 years or longer out of a series of 30 treated for Wilms's tumor at the University of California, is presented. Ten of the 12 patients had been less than 2 years of age when treated, I was 3 years and the other 5 years of age. Five had received postoperative irradiation only. Midplane doses of external radiation (200 kv., half value layer 0.9 mm. Cu) were given, calculated from 1,000 r in 16 days to 3,000 r in 31 days. The remaining 7 each received pre- and postoperative irradiation with the cumulative midplane doses ranging from 2,700 r in 93 days to 5,200 r in 87 days. The records and observation of skin changes showed that the treatment fields crossed the midline in most instances.

In all these patients some effects were evident, either in the bones, soft tissues or skin. All the spines showed roentgenographic traces of the previous radiation effects. These consisted of transverse growth disturbance lines, scalloping, scoliosis, exostosis, irregular epiphyseal lines, abnormal contour of vertebrae, and hypodevelopment. The degree of these changes correlated with the patient's age at the time of irradiation and with the dose administered. The younger the patient and the higher the dose, the more severe were the skeletal changes. Skin and soft tissue changes consisting of skin atrophy, telangiectasis, subcutaneous fibrosis, and permanent epilation were present in all of the patients. The weight, height and general body development compared favorably with the measurements at comparable ages in standard tables. Four of the 6 survivors were women past the age of puberty. All had normal menstrual histories and all had conceived at least once. Three of these 4 women had a total of 11 normal children.

The authors feel that in order to minimize the extent of orthopedic deformity, the treatment fields must be meticulously placed and documented with field roentgenograms. Every child subjected to irradiation of the skeletal system should have orthopedic consultation and management. Roentgenograms of the spine throughout the active years of development are of importance, and properly directed physiotherapy may further minimize postural disability.— Donald N. Dysart, M.D.

Rubin, Philip, Duthie, Robert B., and Young, Lionel W. The significance of scoliosis in postirradiated Wilms's tumor and neuroblastoma. *Radiology*, Oct., 1962, 79, 539–559. (Address: 260 Crittenden Boulevard, Rochester 20, N. Y.)

It is recognized that scoliosis frequently develops in the longterm survivor who has received radiotherapy for certain childhood axial tumors, such as Wilms's tumor and neuroblastoma. The question has been raised whether the degree of scoliosis is too debilitating to warrant the routine use of irradiation in conjunction with surgery. Also the degree of deformity must be weighed against the risk of recurrence of the tumor with loss of life if irradiation is denied. Consequently, the authors have studied 12 cases in which there was measurable scoliosis produced by irradiation of these childhood tumors. The longitudinal studies of these children ranged from 5 to 25 years. All were less than  $1\frac{1}{2}$  years of age at the time of treatment and all received doses of 3,000 r or above.

In general the roentgenographic vertebral changes are rarely perceptible before one year post-irradiation and are related to dose and age more than to other factors. Other findings, in addition to the vertebral changes that may contribute to the scoliosis, include pelvic, rib and soft tissue alterations. It was noted that the degree of scoliosis which developed was not related to the fields of irradiation, whether they were unilateral or bilateral, nor was it related to the severity of the osseous changes in the vertebrae, pelvis, or ribs. Significantly, none of these curvatures disappeared with increasing age nor has there been any further deterioration in the degree of curvature. These findings differ from the usual course and behavior of infantile idiopathic scoliosis which usually deteriorates into the most severe of all spinal deformities. Five of the 12 children have passed through the mid-growth spurt and one through the adolescent growth spurt with no changes in the scoliosis.

The authors discuss the value of irradiation in all cases of Wilms's tumor and neuroblastoma. It is felt that when there is residual gross or microscopic tumor the value of irradiation can hardly be challenged and the late bone changes are quite acceptable in view of the long survival which results. The usefulness of irradiation in cases where a completely encapsulated tumor has been removed and where there is no evidence of invasion is questioned. Individualization of cases is advisable, particularly in infants under 18 months, where the prognosis for survival is excellent. In cases of abdominal neuroblastoma with tumor destruction of the pedicles irradiation is indicated, not only for survival reasons, but also to decrease the resultant deformity of the spine by arresting growth of the partially destroyed vertebrae so as not to increase the wedging effect of unilateral growth.

The authors do not believe that irradiation of the entire width of the vertebrae will avoid unilateral wedge effect with resultant scoliosis. Four of the cases in this study had unilateral changes resulting in scoliosis even though the entire transverse diameter of the vertebrae was treated. They do feel that it is important to avoid including the iliac crest in the treatment field if at all possible. The acetabular fossa and femoral head should always be outside the field to prevent moderate to severe deformities.—Donald N. Dysart, M.D.

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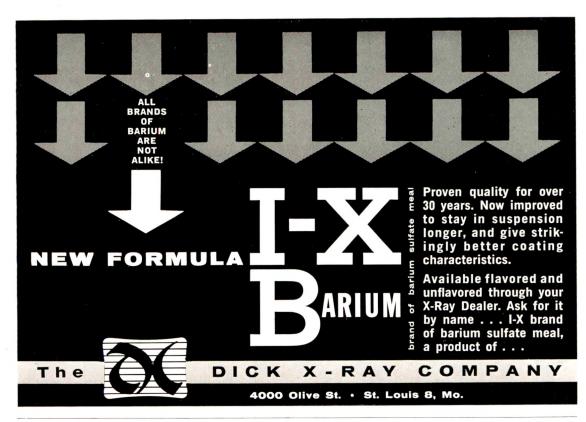
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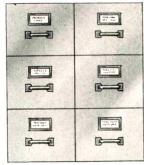
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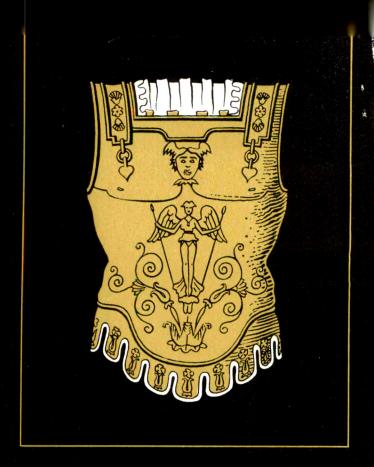
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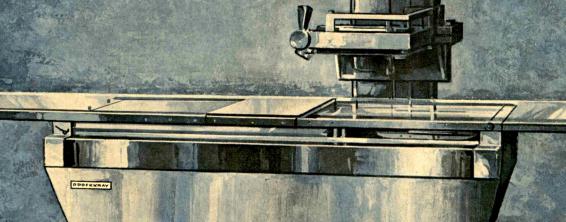
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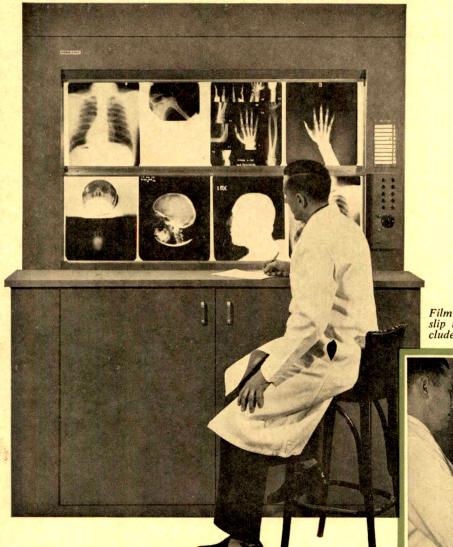
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Excellent visualization, minimal discomfort following injection—these are the features of Renografin (Methylglucamine Diatrizoate Injection U.S.P., Squibb) in cerebral angiography. <sup>1-3</sup> It also produced similarly impressive results in abdominal aortography. <sup>4-5</sup> Most reactions reported were of a transient nature. <sup>1-3,5</sup>

"Superior contrast media" in intravenous urography

In three large series, diagnostic films were produced in over 90% of patients of all ages. No serious or severe reaction occurred, and minor side effects were remarkably few.<sup>6-8</sup>

# RENOGRAFIN® METHYLGLUCAMINE DIATRIZOATE INJECTION U.S.P., SQUIBB

Dosage and Administration for Excretion Urography: Renografin-76 (methylglucamine diatrizoate) - 20 cc. by slow I.V. injection (adults), and 4-20 cc. I.V. or I.M. (children). Renografin-60 (methylglucamine diatrizoate) - 25 cc. by slow I.V. injection (adults), and 5-25 cc. I.V. or I.M. (children).

Supply: Renografin-76 (Methylglucamine Diatrizoate Injection U.S.P.) providing 76% methylglucamine diatrizoate – combination package of 20 cc. and 1 cc. ampuls; and 20 cc. vials. Renografin-60 (Methylglucamine Diatrizoate Injection U.S.P.) providing 60% methylglucamine diatrizoate – combination package of 25 cc. and 1 cc. ampuls; and 25 cc. and 100 cc. vials. Both preparations also contain 0.3% sodium citrate as a buffer, 0.04% disodium ethylenediamine tetraacetate dihydrate as a sequestering agent and sodium hydroxide to adjust pH. Vials contain 0.1% methylparaben and 0.03% propylparaben as preservatives.

Side effects: Flushing, nausea, and vomiting.

Precautions: I.V. test dose should be given. Examination should be stopped upon evidence of allergy to the test dose. In rare instances, despite the most careful sensitivity testing, anaphylactoid reactions may occur. Use with caution in severely debilitated patients and in cyanotic infants, patients with chronic pulmonary emphysema, advanced arteriosclerosis, severe hypertension, cardiac decompensation, and recent embolism or thrombosis. For full information, see your Squibb Product Reference or Product Brief.

References: (1) Doehner, G. A., and Brugger, G. E.: New York J. Med. 60:4022, 1960. (2) Balkissoon, B., et al.: J.A.M.A. 169:676, 1959. (3) Gensini, G. G., and Ecker, A.: Radiology 75:885, 1960. (4) Agnew, C. H., and Cooley, R. N.: Texas J. Med. 55:945, 1959. (5) Greenspan, R. H., et al.: Am. J. Roentgenol. 83:1034, 1960. (6) Utz, D. C., and Thompson, G. J.: Proc. Staff Meet. Mayo Clin. 33:75, 1958. (7) Orr, L. M., et al.: J.A.M.A. 169:1156, 1959. (8) Mathews, P. W., Jr.: South. M. J. 52:170, 1959.

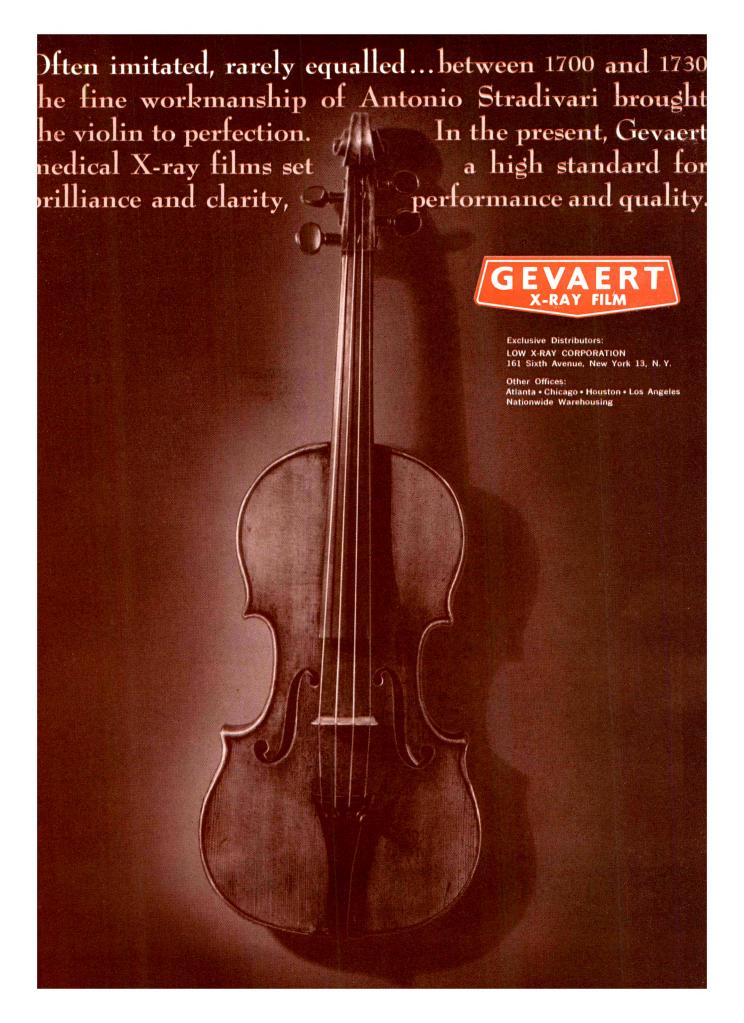
# ASK THE HOSPITALS THAT USE IT

It is significant that over the past five years more than a score of important hospitals from coast to coast have installed Siemens three phase x-ray equipment. In order that you may obtain first hand adequate testimony to the advantages of this equipment, a list of installations is available on request.

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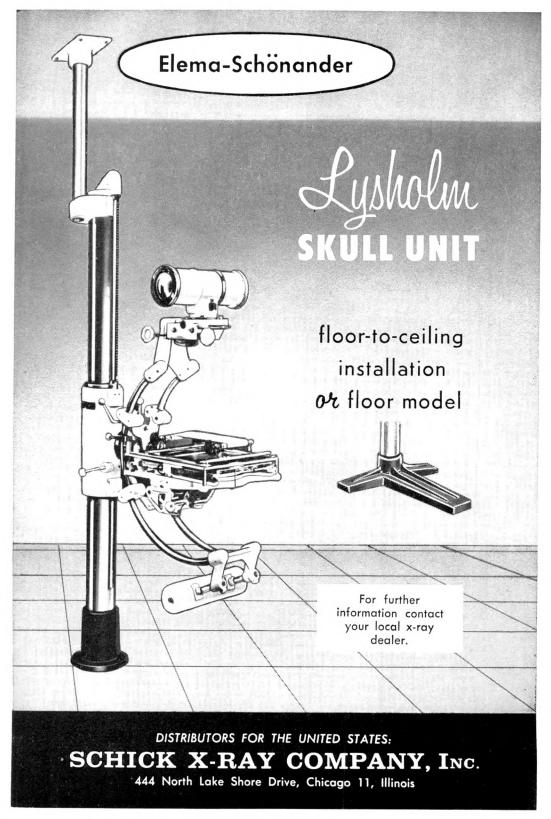
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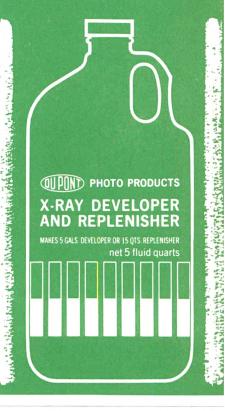




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#### For precise and accurate x-ray determination of



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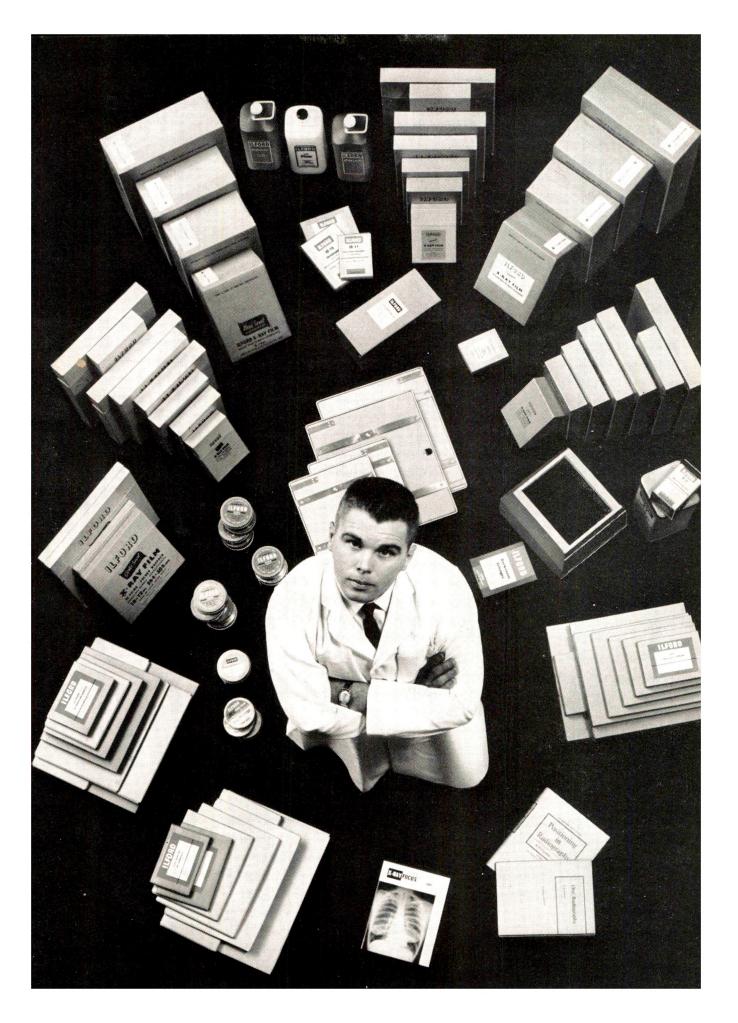
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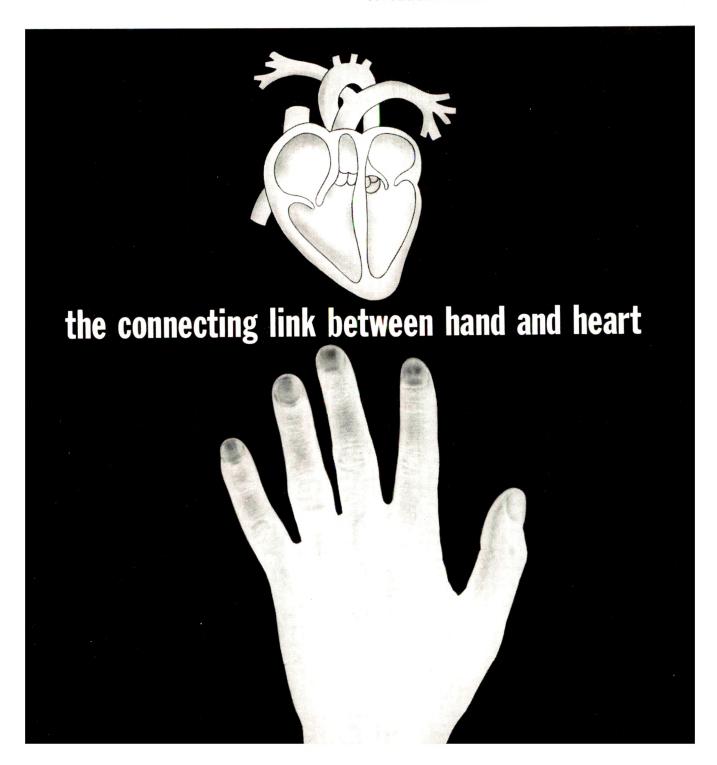
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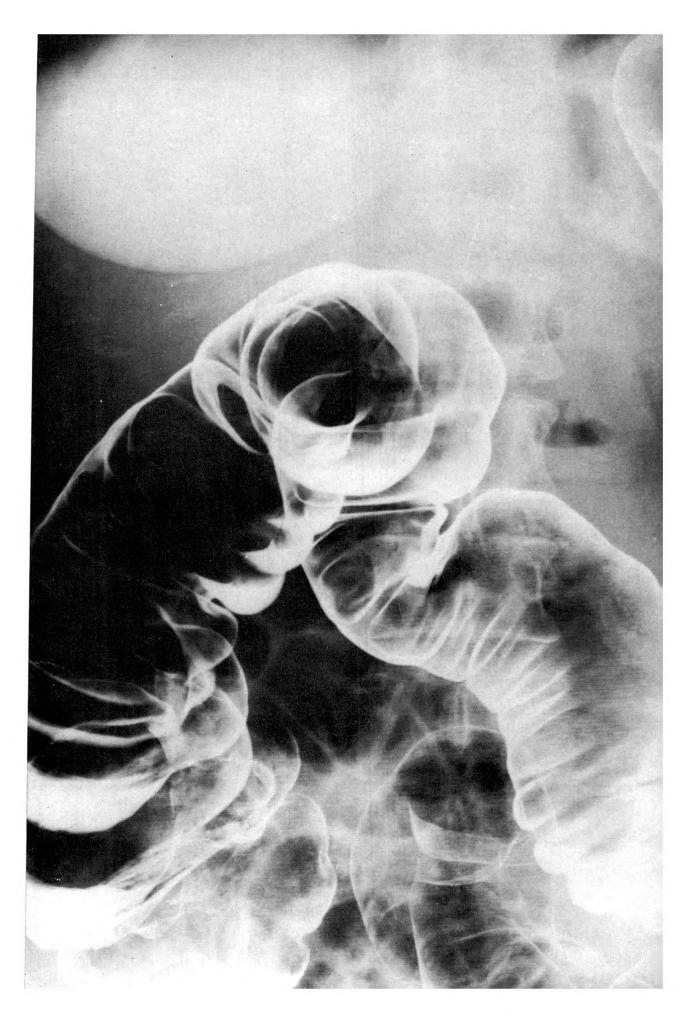
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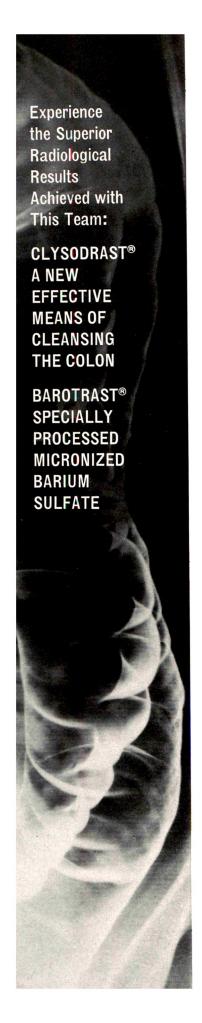
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drast is an effective means of cleansing and preparing the colon for radiologic examination. The effective agent in Clysodrast is a nonirritant which stimulates the musculature to contract. The tannic acid has a favorable influence on the deposition of Barotrast on the mucosa and aids in preparation of the colon. Clysodrast is available in the United States exclusively through Barnes-Hind. Each Clysodrast pack contains 1.5 mg. of 4,4' (diacetoxydiphenyl)-(pyridyl-2)-methane, complexed with 2.5 gm. of Tannic Acid N.F., in a readily soluble form.

A specially processed and micronized form of barium sulfate, Barotrast possesses unparalleled properties of flow, coating, and water retention which are not normally affected by mucin content, enzymes, or changes in pH encountered in routine use. Its unique adherence to the intestinal mucosa produces a uniform, stable and flexible coating. When administered orally, it flows through the bowel as a column without clumping, precipitating, or forming concretions. Barotrast is known for its routine ability to provide exceptional radiological results in double contrast, upper GI, and small bowel studies.

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Note: Consult Barnes-Hind's literature regarding directions for use of Barotrast. Clysodrast should be employed with caution when colitis is known to exist, although its use in colitis without adverse reactions has been reported. Incidence of cramping, weakness, nausea, and fainting is greater with Clysodrast than with less effective enemas. Warning: Clysodrast preparations should be used with great care in patients where old age, debility, cardiovascular or other diseases are present.

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#### How to eliminate Rotational Therapy

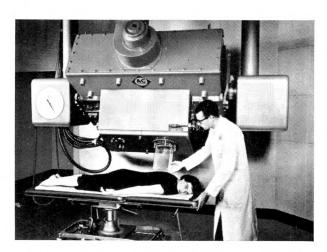
As the graph shows, Betatron's greater energy penetrates deeper . . . with less damage to intervening tissue. In addition, the exit dose is not dangerously increased. In the case of electron therapy, the sharp cut-off reduces the exit dose to zero, making the Betatron a safe tool for therapy in the delicate heart and brain areas.

**25** Mev therapy is quick and sure. Because the focal point size is only 0.2mm, and the entrance and exit doses are less than the treatment dose—you're able to aim the Betatron more precisely, deliver the dose more rapidly. In addition, you choose the depth of radiation, since the A-C Betatron operates in the preferred 10 to 25 Mev range.

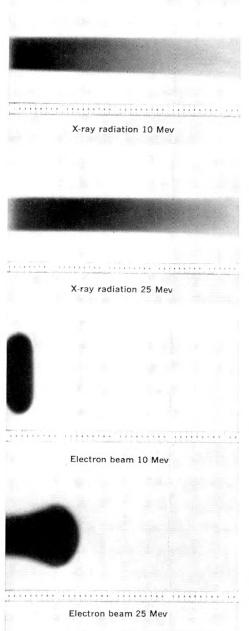
Variable dosage makes portal technique practical. The 2 or 3-portal technique available with the Betatron achieves better results than complex rotational therapy in less time, with fewer treatments. Your patient undergoes less discomfort, and your operating costs are reduced.

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A-1749



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#### blood volume?

- pre-operative transfusion necessary?
- post-operative replacement, maybe?
- blood loss during surgery?
- G.I. hemorrhage?
- hypervolemia?
- red cell survival?
- guidance for anesthesiologist?



#### automatic measurement can resolve them...

- by providing rapid determination of the patient's circulating blood volume
- by using radioisotope dilution techniques and errorproof programmed operation
- with accurate digital readout to nearest 10 ml
- needs only small blood sample
  - no preparative delay: dosage is prepackaged
- repeat tests any time

#### without capital investment.

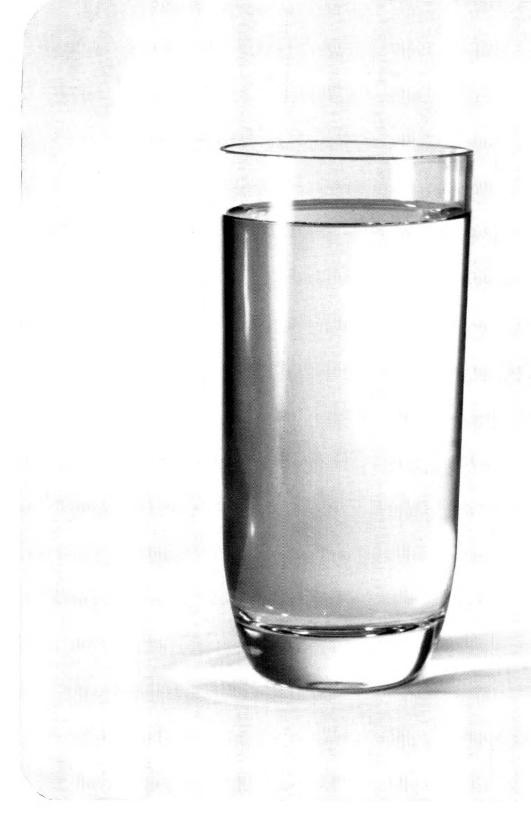
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This glass contains one reason General Aniline & Film Corp. located its film-making facilities in Binghamton, New York—water. Nothing more common... nothing more varied, chemically. And this water, from one of 12 deep wells is chemically perfect for X-ray film manufacture. Yet, as perfect as it is, we improve it even more. It's just one of the reasons Ansco X-ray films are the finest you can use.

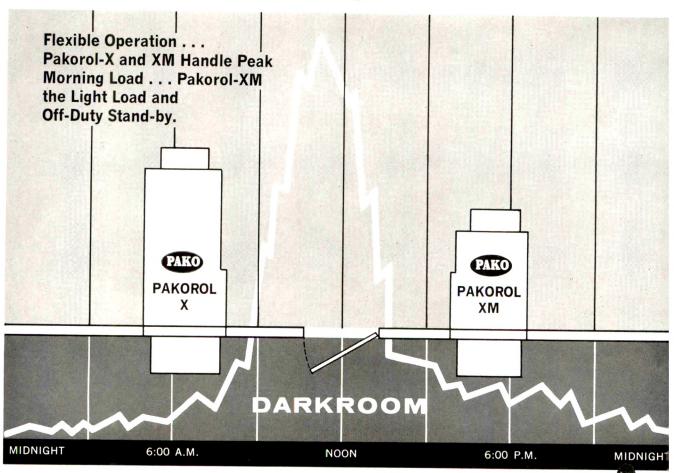
It's one reason you can be "Anscosure" of the finest radiographs possible every time you make an exposure. For your work, you ought not accept anything less.

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### Plan solves processing problem of busy morning...light afternoon



#### Dual installations...

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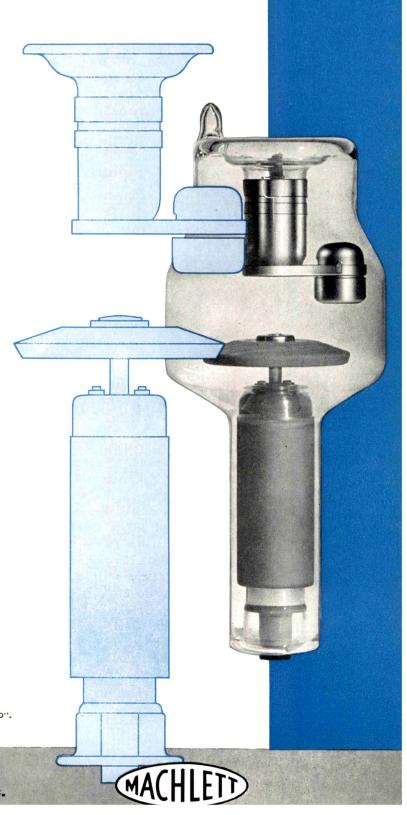
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In preparation for G.I.series, barium enema, cholecystography, and pyelography, the contact laxative, Dulcolax, has proved distinctly superior in cleansing action to the traditional castor oil and/or enema routine.<sup>1-3</sup>

The result is clearer, sharper pictures, unobscured by shadows attributable to gas or fecal residue. The use of Dulcolax also obviates the accidental introduction of air sometimes caused by enemas.

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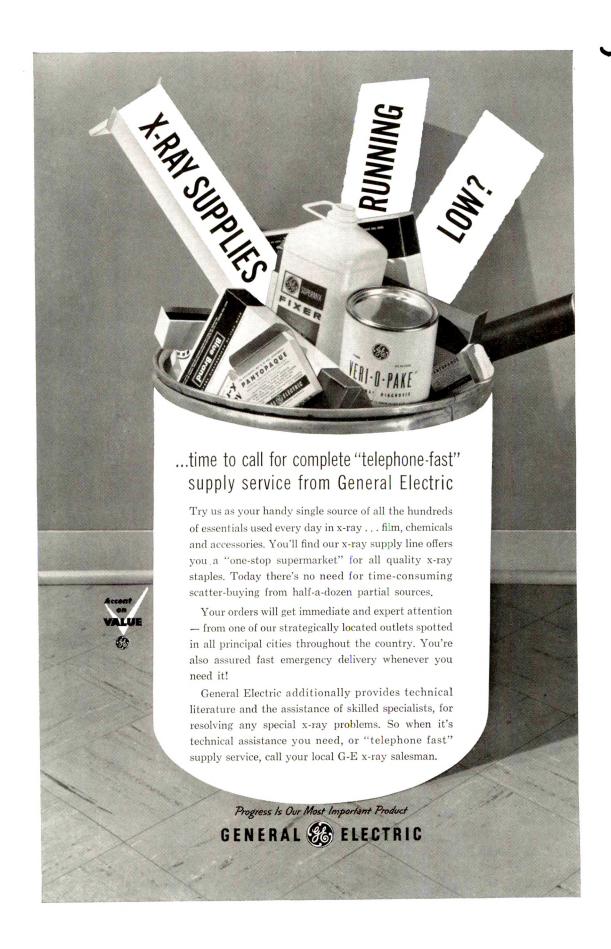
<u>Contraindications</u>: There are no contraindications to Dulcolax other than in an acute surgical abdomen and intestinal obstruction.

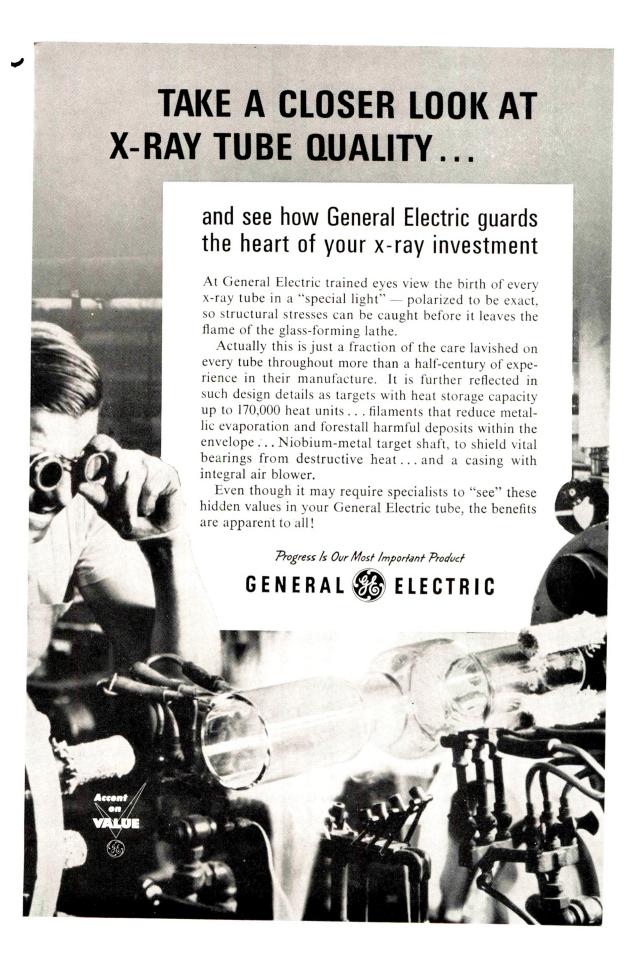
Availability: Dulcolax®, brand of bisacodyl: Tablets of 5 mg. in boxes of 6 and bottles of 100 and 1,000; suppositories of 10 mg. in boxes of 2 and 50. Under license from Boehringer Ingelheim G.m.b.H.

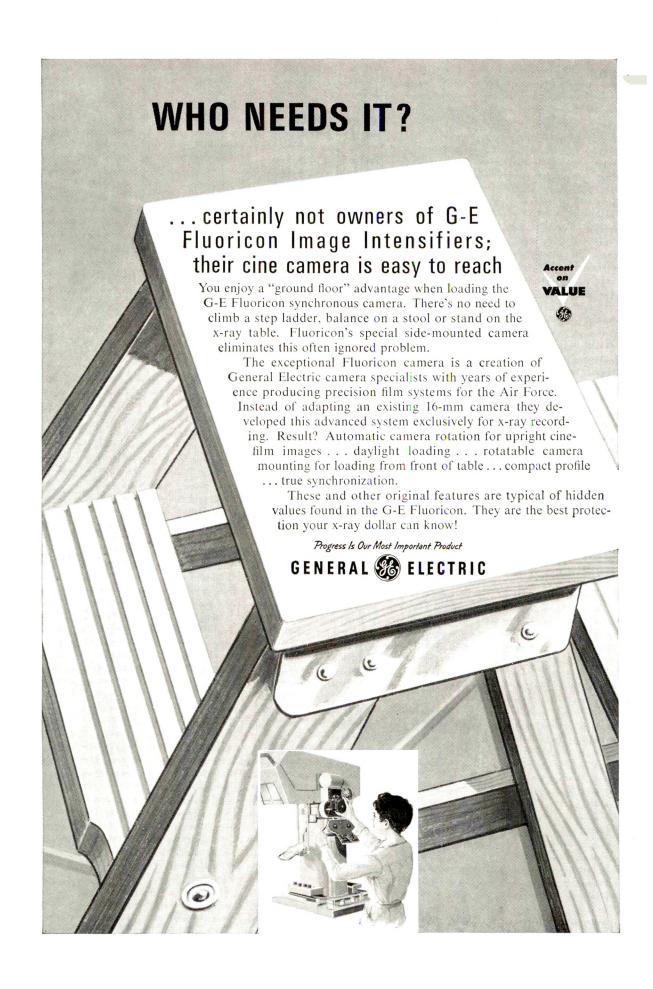
1. Poppel, M.H., and Bangappa, C.K.: Am. J. Roentgenol. 81:696, 1959. 2. Keogh, R.K., and Fraser, R.G.: J.A. Canad. Radiol. 9:66, 1958. 3. Raymond, O.; Nogrady, B., and Vezina, J.: Canad. M.A.J. 82:1077, 1960. 4. Eid, C. H.; Martel, W., and Tupper, C. J.: J. Michigan M. Soc. 60:1546, 1961.



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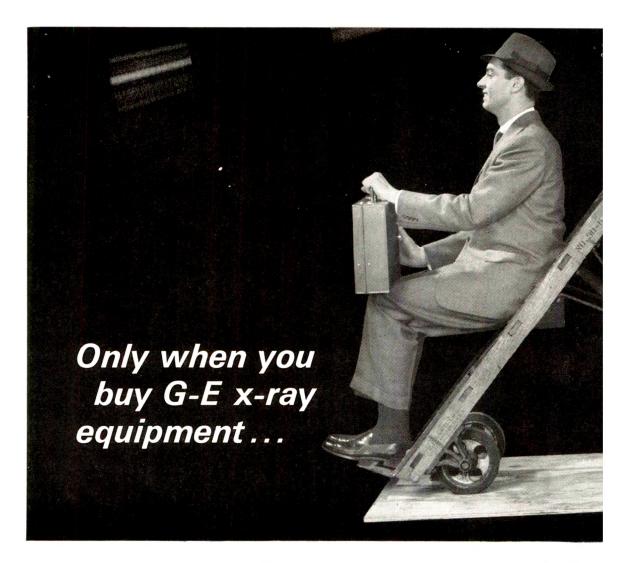
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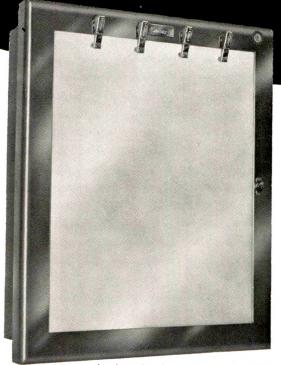


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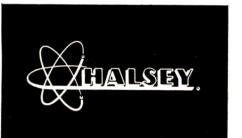
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REFERENCES: 1. Statman, A. J.: Am. J. Gastroenterol. 33:740 (June) 1960. 2. Murphy, T. E.: J. Urology 86:659 (Nov.) 1961. 3. McGrattan, V. T.: J. Abdominal Surgery 3:178 (Nov.) 1961.

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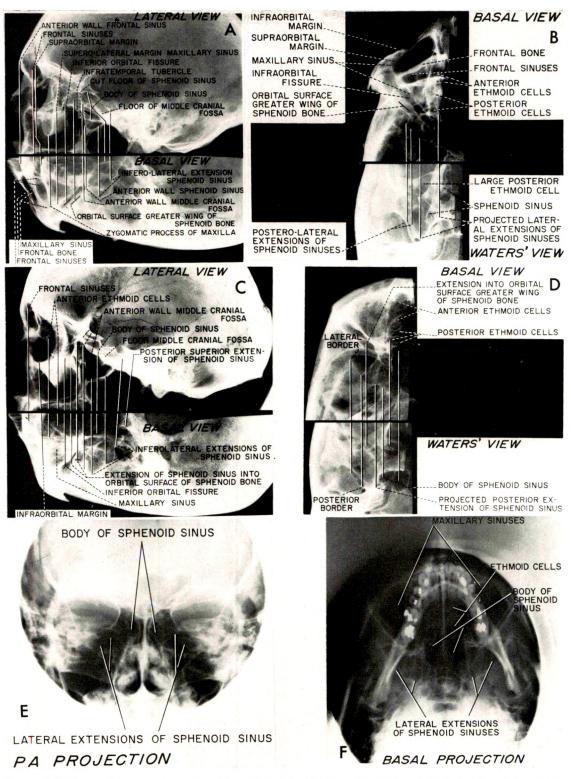


Fig. 2. (A) Composite roentgenogram of lateral and basal view of a sectioned skull showing the roentgen anatomic features of the paranasal sinuses and middle cranial fossa. (B) Composite roentgenogram of basal and Waters' view of sectioned skull showing roentgen anatomic features. (C) Composite roentgenogram of lateral and basal view of another sectioned skull showing roentgen anatomic features of the sphenoid sinuses, their lateral recesses and other associated roentgen anatomic features. (D) Composite roentgenogram of basal and Waters' view showing delineation of the roentgen anatomic features of the sphenoid sinuses and their lateral recesses as well as related roentgen anatomic features. (E) Standard posteroanterior projection for paranasal sinuses showing lateral extensions of the sphenoid sinus. (F) Basal projection of skull for paranasal sinuses demonstrating lateral extensions of the sphenoid sinuses.

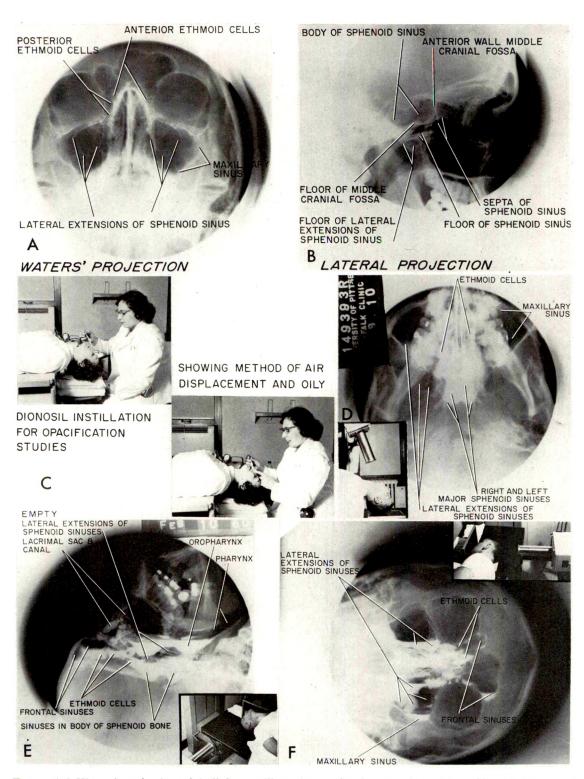


Fig. 3. (A) Waters' projection of skull for maxillary sinuses showing superimposition of lateral recesses of the sphenoid sinuses upon them. (B) Lateral view of skull and paranasal sinuses showing extent of lateral recesses of the sphenoid sinuses. (C) Photographs showing the air displacement method of withdrawing air and instilling oily dionosil. (D) Submentovertical projection showing distribution of oily dionosil in the body of the sphenoid sinus with empty lateral extensions. (E) Lateral projection of the submentovertical position showing filling of the sphenoid sinuses with empty lateral extensions. (F) Right lateral decubitus position in the maxillary sinus projection showing filling of the lateral extension of the sphenoid sinus superimposed upon the maxillary sinus.

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### OPACIFICATION STUDIES OF NORMAL AND ABNORMAL PARANASAL SINUSES\*

By LEWIS E. ETTER, M.D.†
PITTSBURGH, PENNSYLVANIA

COME skulls have been sectioned in the O mid-sagittal and horizontal planes to show variations of the paranasal sinuses, particularly those of the sphenoid sinuses because of their direct relation to the middle cranial fossa (Fig. 1A). It will be seen that the fully developed sphenoid sinus occupies more or less of the body of the sphenoid bone, but also may have extensions or recesses laterally, backward, or forward. These recesses, like the sinus itself, rarely develop symmetrically (Fig. 1B). Of all the recesses, the lateral one is the most frequently observed and usually the largest. It pneumatizes the sphenoid bone where the root of the pterygoid process joins the horizontal part of the greater wing, but may occasionally extend to the infratemporal crest (Fig. 1, C and E) and the orbital surface of the greater wing of the sphenoid bone. Fairly frequently it may extend upward into the vertical part of the greater wing or downward into the pterygoid processes of the sphenoid bone (Fig. 1D). Pneumatization of a pterygoid process extending below

the floor of the sphenoid sinus may add some clinical significance because it provides a pocket for accumulation of secretions and increases the difficulty of drainage of the sinus. In a series of 142 sphenoid sinuses studied in dry skulls, the lateral recess was found to be present in 48 per cent or almost half of them.\*

In Figure 2A, a rather crowded composition, sections have been matched of the lateral projection of a dry skull and its basal component, showing the position of the lateral and inferior extensions of the sphenoid sinuses and their relation to the middle cranial fossa. The wall of the middle cranial fossa and the lateral extension of the sphenoid sinus which extends inferiorly into the pterygoid process of the bone and also into the orbital process of the greater wing of the sphenoid is delineated. In Figure 2B a comparison is made of the basal with the Waters' projection, showing how the lateral

<sup>\*</sup> Studied by Dr. Jacob Priman, Prof. of Anatomy, School of Medicine, University of Pittsburgh.

<sup>\*</sup> Presented at the Sixty-second Annual Meeting of the American Roentgen Ray Society, Miami Beach, Florida, September 26–29,

<sup>†</sup> Western Psychiatric Institute and The Falk Clinic, School of Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania.

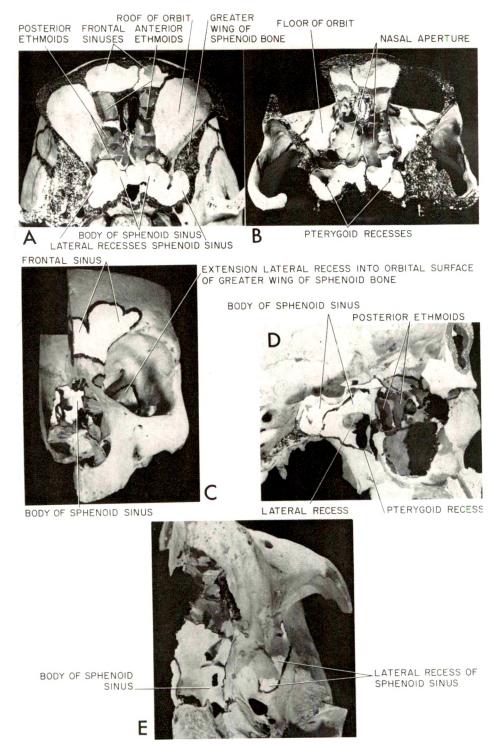


Fig. 1. (A) Superior portion of sectioned skull showing anatomic features of frontal, ethmoid, and sphenoid sinuses. (B) Inferior portion of sectioned skull showing frontal, ethmoid, and sphenoid sinus components. (C) Frontal view of sectioned skull showing extent of sphenoid and frontal sinuses. (D) Side view of midsagittal section of skull showing position and extent of sphenoid and ethmoid cells. (E) Inferior view of base of skull showing body of sphenoid sinus and lateral recess.

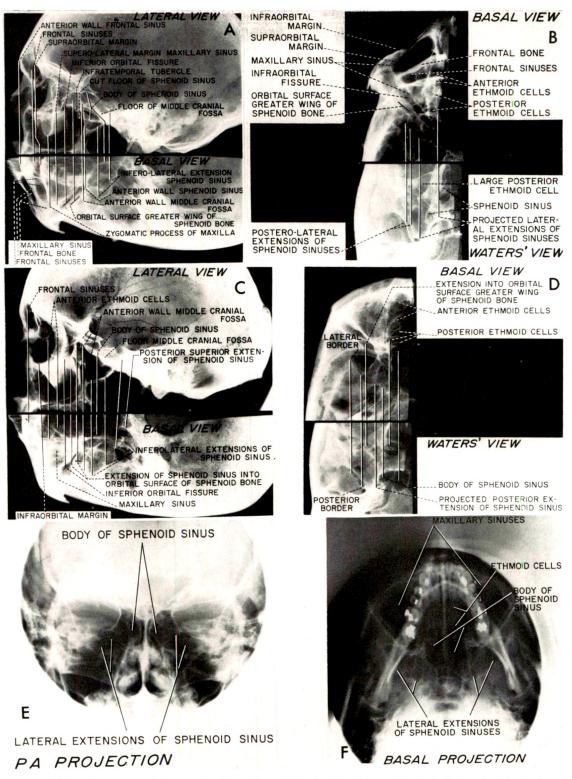


Fig. 2. (A) Composite roentgenogram of lateral and basal view of a sectioned skull showing the roentgen anatomic features of the paranasal sinuses and middle cranial fossa. (B) Composite roentgenogram of basal and Waters' view of sectioned skull showing roentgen anatomic features. (C) Composite roentgenogram of lateral and basal view of another sectioned skull showing roentgen anatomic features of the sphenoid sinuses, their lateral recesses and other associated roentgen anatomic features. (D) Composite roentgenogram of basal and Waters' view showing delineation of the roentgen anatomic features of the sphenoid sinuses and their lateral recesses as well as related roentgen anatomic features. (E) Standard posteroanterior projection for paranasal sinuses showing lateral extensions of the sphenoid sinus. (F) Basal projection of skull for paranasal sinuses demonstrating lateral extensions of the sphenoid sinuses.

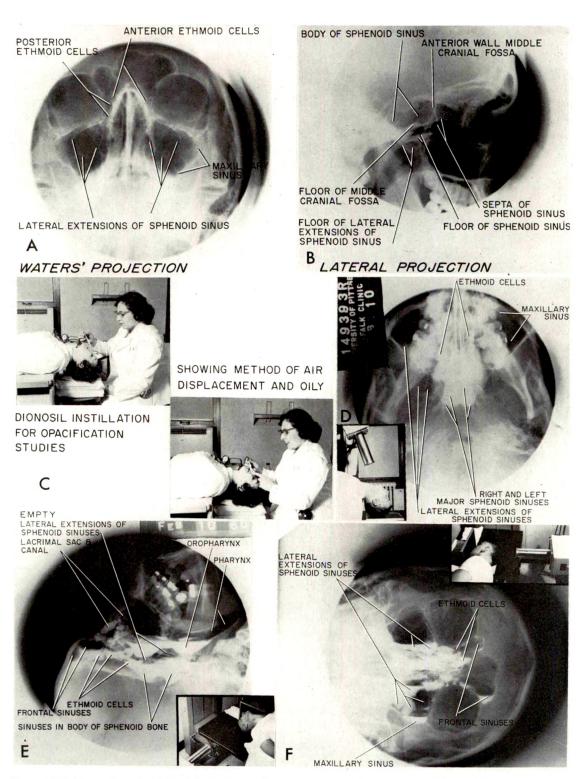


Fig. 3. (A) Waters' projection of skull for maxillary sinuses showing superimposition of lateral recesses of the sphenoid sinuses upon them. (B) Lateral view of skull and paranasal sinuses showing extent of lateral recesses of the sphenoid sinuses. (C) Photographs showing the air displacement method of withdrawing air and instilling oily dionosil. (D) Submentovertical projection showing distribution of oily dionosil in the body of the sphenoid sinus with empty lateral extensions. (E) Lateral projection of the submentovertical position showing filling of the sphenoid sinuses with empty lateral extensions. (F) Right lateral decubitus position in the maxillary sinus projection showing filling of the lateral extension of the sphenoid sinus superimposed upon the maxillary sinus.

recesses of the sphenoid sinuses may be projected over the maxillary sinuses, and also showing pneumatization of the orbital surface of the greater wing of the sphenoid bone. A comparison of lateral and basal views of another skull showing these variations is seen in Figure 2C. In this skull there is extensive pneumatization of the pterygoid process extending laterally into the greater wing of the sphenoid bone, but not pneumatizing its orbital surface. The anterior wall of the middle cranial fossa is quite distinct from the sphenoid sinus which extends considerably below it although, on the basal view, the anterior wall of the sphenoid sinus appears to coincide with the margin of the recess of the sphenoid sinus. Similarly (Fig. 2D), a comparison of the basal and the maxillary sinus views shows how the lateral recesses of the sphenoid sinus may be projected in the Waters' view over the maxillary sinus. This may be important clinically, as will be discussed below, when disease of a lateral extension of the sphenoid sinus may appear to be in the maxillary sinus.

On a plain roentgenogram of the paranasal sinuses, a posteroanterior projection may show lateral extensions or recesses of the sphenoid sinus (Fig. 2E). The basal projection (Fig. 2F) shows much more clearly the true situation with evidence of pneumatization of the greater wing of the sphenoid bone extending far laterally below the middle cranial fossa and approaching the orbital surface of the greater wing. The maxillary sinus view (Fig. 3A) reveals, on careful examination, definite evidence of lateral recesses of the sphenoid sinuses in back of the maxillary sinuses. In the lateral view (Fig. 3B) these features are not as evident but can, nevertheless, be seen on close examination extending well below the level of the floor of the middle cranial fossa and into the bases of the pterygoid processes. In order to delineate these variations clearly, we have used the air displacement technique of Proetz and oily dionosil instillations as illustrated in Figure 3C, which shows the resident physician dropping oily dionosil into one nostril at a time, and using

a suction apparatus to withdraw air and replace it with the opaque medium to a total of 20 cc. The first roentgenographic position (Fig. 3D) shows the submentovertical proiection from above and indicates that the lateral recesses of the sphenoid sinuses are in a more caudad position than the body of the sphenoid sinus since only the body is filled when the lateral extensions are not. The lateral view of the patient in this position (Fig. 3E) confirms the different levels of filling, showing opaque medium in the body of the sphenoid sinus, in the ethmoid cells and in the oropharynx and nasopharynx with the lateral recesses empty. By turning the patient on the right side and directing the central ray with the skull in the Waters' position (Fig. 3F), projection of these lateral extensions of the sphenoid sinuses over the maxillary sinuses is well demonstrated.

In Figure 4A marked symmetry of the lateral extensions of the sphenoid sinuses is shown with the patient resting on the opposite side of his head. The right optic foramen projection (Fig. 4B) reveals the relationship of the posterior ethmoid cells to the body of the sphenoid sinus and its lateral extensions, as well as a similar appearance on the left side (Fig. 4C) with the same situation seen, since these recesses are so bilaterally symmetric. In the next position (Fig. 4D) with the patient chin down for the verticosubmental projection, it is seen that the body of the sphenoid sinus has emptied and filled the more caudad lateral recesses of these sinuses. It is also verified that they extend laterally behind the maxillary sinuses. Then the patient is turned on his back and an anteroposterior oblique roentgenogram in the Chamberlain-Towne projection is exposed (Fig. 4E). Again emptying of the posteroinferior parts of the central portion of the sphenoid sinus and filling of its lateral extensions is demonstrated. With the patient upright, in the Waters' view (Fig. 4F), fluid levels can be distinguished in the frontal sinuses and ethmoid cells as well as in the lateral recesses of the sphenoid sinuses superimposed upon the maxillary sinuses. An erect lateral

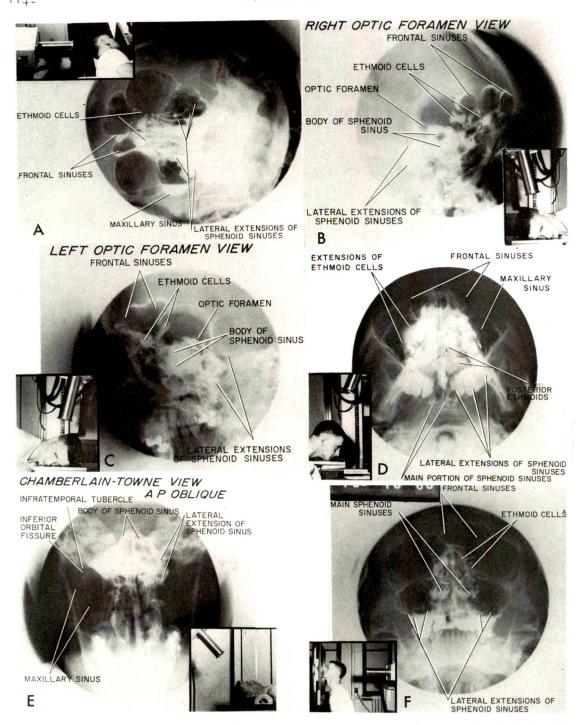


Fig. 4. (A) Left lateral decubitus Waters' projection showing symmetry of the lateral extensions of the sphenoid sinuses in this patient. (B) Right optic foramen view demonstrating frontal, ethmoid, sphenoid sinuses, and lateral recesses. (C) Left optic foramen view showing a similarity of the paranasal sinuses on each side. (D) Verticosubmental projection of the oil filled sinuses demonstrating filling of the lateral extensions and emptying of the main body of the sphenoid sinuses. (E) Chamberlain-Towne projection showing bilateral symmetry of the filled lateral recesses with emptying of the main body of the sphenoid sinuses. (F) Erect maxillary sinus view demonstrating different levels of filling in the main sphenoid sinuses, their lateral recesses and the maxillary sinuses.

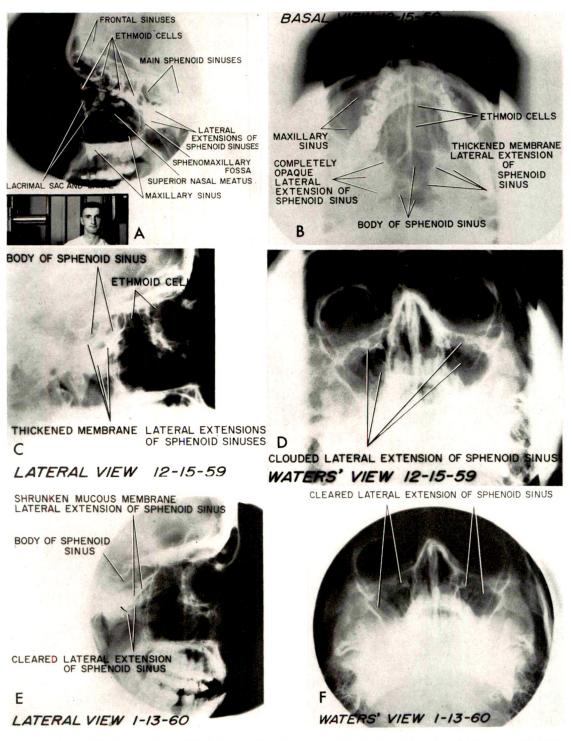
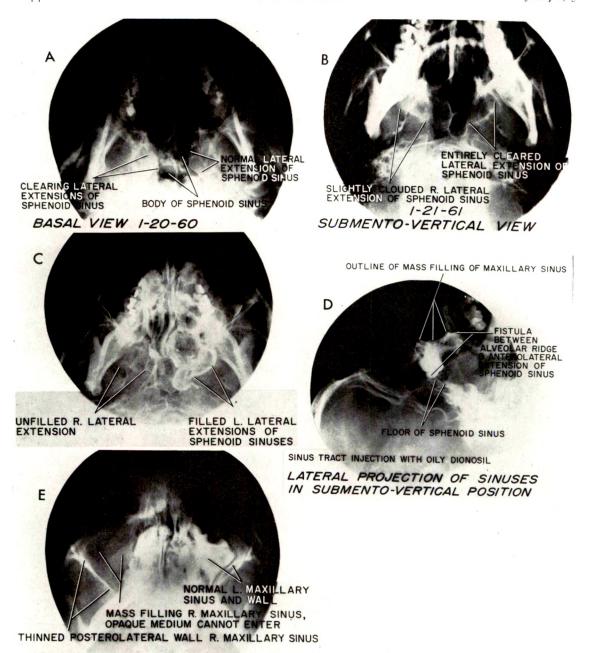


Fig. 5. (A) Upright lateral view of filled sinuses showing empty main body of the sphenoid sinuses with filling of the lateral extension. (B) Basal view of paranasal sinuses showing completely opaque lateral extension on the right side and thickened lining membrane on the left side. (C) Lateral view showing thickened membrane of the lateral extensions of the sphenoid sinuses. (D) Waters' view showing thickened membrane of the lateral extensions of the sphenoid sinuses projected over maxillary sinuses. (E) Follow-up lateral view showing shrinking of the mucous membrane of the lateral extensions of the sphenoid sinuses. (F) Follow-up Waters' view also demonstrating clearing of the lateral extensions of the sphenoid sinuses as they are projected over the maxillary sinuses.



### VERTICO-SUBMENTAL PROJECTION

Fig. 6. (A) Basal view showing marked clearing of the lateral recesses of the sphenoid sinuses. (B) Follow-up submentovertical views a year later demonstrating further clearing of the lateral recesses of the sphenoid sinuses. (C) Basal view following instillation of oily dionosil showing filling of entirely cleared left lateral extension of the sphenoid sinuses, but with unfilled right lateral extension presumably due to continued edema of the mucous membrane. (D) Lateral view following oil instillation of the paranasal sinuses with the patient in the anteroposterior decubitus position demonstrating fistula between the alveolar ridge and anterolateral extension of the sphenoid sinus. (E) Verticosubmental projection of the same patient showing mass filling the right maxillary sinus and erosion of its right posterolateral wall and normal oil filling of the left maxillary sinus with exception of polypoid thickening of its lining membrane.

projection (Fig. 5A) shows draining of most of the opaque medium from frontal and ethmoid sinus cells and the body of the sphenoid sinus with complete filling of the lateral recesses of the sphenoid sinuses because they are in a caudad position. Also it should be noted that they are completely behind the maxillary sinuses, where a small amount of the opaque medium shows a fluid level over the alveolar processes of the maxillary bones.

An interesting case is that of a 22 year old female having continued paranasal sinus symptoms, thought to be due to maxillary sinusitis, who was found to have disease in the lateral recesses of the sphenoid sinuses. Figure 5B shows almost complete opacity in the lateral extension of the sphenoid sinus on the right side and marked thickening of the lining membrane of the lateral extension of these sinuses on the left side. The upright lateral view at the same time (Fig. 5C) shows thickening of the lining membrane of these lateral extensions clearly. The Waters' view (Fig. 5D) demonstrates clouding of these lateral extensions of the sphenoid sinuses superimposed upon the maxillary sinuses. After treatment was instituted, in approximately one month's time, there was considerable clearing of the thickened mucous membrane (Fig. 5E) as seen in the lateral view and in the Waters' projection (Fig. 5F).

Even more striking is the appearance of the basal view (Fig. 6A), showing marked shrinking of the previously thickened mucous membrane and clearing of the lateral extensions of the sphenoid sinuses. The patient returned for another examination a year later presenting an almost entirely cleared lateral extension of the sphenoid sinus on the left side (Fig. 6B) with slight residual clouding on the right side. At this time oily dionosil was instilled again according to the system outlined above, and on a comparative basal view (Fig. 6C) it is seen that the lateral extension of the sphenoid sinus is completely filled with dionosil on the left side with residual edema of the membrane lining the ostium on the right side. This lateral extension did not fill, although it shows much less clouding than at the time of the original examination.

Another case of interest is that of a 45 year old white male with a fistula and mass demonstrated in the right maxillary sinus following operation for a so-called benign tumor of the palate. From the lateral projection (Fig. 6D) of the verticosubmental position after instillation of opaque medium through a trocar into the fistulous opening in the right maxillary ridge, it was seen that the connection was between an anterolateral recess of the sphenoid sinus rather than merely involvement of the maxillary sinus as had been clinically supposed. The air displacement method with oily dionosil instillation was employed in the next pa-The verticosubmental projection (Fig. 6E) reveals that none of the opaque medium has entered the right maxillary sinus which is filled with a mass, but a normal outlining of the left maxillary sinus is seen. Only a small polypoid thickening of its mucous membrane is seen anteriorly. It will also be noted in this roentgenogram that there is definite thinning of the posterolateral wall of the right maxillary sinus as compared with the normal left side and its posterolateral wall. Following this examination an operation was performed on the right maxillary sinus and a pathologic diagnosis of chronic granuloma was made.

### CONCLUSION

It may be concluded that radiologists should be more conscious of considerable variation of the paranasal sinuses, especially of the sphenoid sinuses which may be present in as many as 48 per cent of the cases. More definitive information of the exact extent of these sinuses can be obtained by the air displacement technique and the use of an opaque medium such as oily dionosil.

Western Psychiatric Institute and The Falk Clinic School of Medicine University of Pittsburgh 3811 O'Hara Street Pittsburgh 13, Pennsylvania

# RESIDUAL THOROTRAST IN THE PARANASAL SINUSES\*

## A STUDY OF ITS ROENTGEN APPEARANCE AND IMPLICATIONS

By FRIEDA FELDMAN, M.D., WILLIAM B. SEAMAN, M.D., and JOSEPHINE S. WELLS, M.D. New York, New York

CINCE its first reported use by Radt in 3 1930,15 numerous articles alluding to the dangers of thorotrast as a potential carcinogenic agent have appeared in the world literature with a resulting decline in its popularity as a diagnostic radiopaque agent. Until quite recently, however, its excellent qualities as a contrast medium caused it to be employed extensively in a host of procedures including cerebral and peripheral arteriography, myelography, ventriculography, mammography, salpingography, cholangiography, bronchography, gastrointestinal roentgenography, hepatography, splenography and the visualization of sinus tracts and the paranasal sinuses. Its use for intrasinusal injections is of particular interest to the authors, since in the period from 1955 to 1962, 7 cases of residual thorotrast within a paranasal sinus were encountered at the Columbia-Presbyterian Medical Center.

It is the intent of this paper to emphasize the frequent use of thorotrast in the past for intrasinusal instillation and to call attention to the fact that it may be retained as a foreign body for a long period of time. Recognition of retained thorotrast is important so that it can be removed, either before malignant transformation has occurred, or in its early curable phases.

### PROPERTIES OF THOROTRAST

Thorotrast is the proprietary name of a 25 per cent solution of colloidal thorium dioxide, by volume, in a dextrin medium.<sup>3</sup> The element thorium (estimated half life 1.39×10<sup>10</sup> years) contained in this preparation is the parent substance of a naturally occurring radioactive family whose decay

to mesothorium, radiothorium, thorium X and thorium emanation releases alpha particles, beta rays and gamma rays.

Orr *et al.*<sup>12</sup> called attention to the fact that a freshly prepared sample of thorotrast is not a permanent measure of its emanative properties. The total radioactivity decreases over a period of 5 years (half life of radiothorium) and then begins to rise due to the fact that sufficient radiothorium has broken down to form other members of the radioactive family which are strong alpha emitters. The resultant total radioactivity after 10 years is 54 per cent of that of the original solution. This activity continues to increase, reaching its peak in the next 15 years.

Taft<sup>19,20,21</sup> estimated that in 75 cc. of thorotrast the gamma ray activity is equal to 1.37  $\mu$ g. of radium and the alpha ray activity is equal to 1.5  $\mu$ g. of radium. Thus,

the activity of the average intravenous dose of thorotrast is comparable to the estimated 0.5 to 2.0  $\mu$ g. of radium salts shown to have caused serious tissue damage in persons engaged in painting luminous watch dials. 10,11 Although much smaller quantities are employed in the delineation of sinus cavities, as pointed out by Budin and Gershon-Cohen,2 where the material is permanently retained, the oncogenous effect would still be a definite hazard. They felt that the relatively few cases of malignancy so far reported could be attributed to the long latent period. In the reported cases, the latent periods ranged from 4 to 21 years after instillation of thorotrast in the paranasal

In 1932, the Council on Pharmacy and Chemistry of the AMA<sup>3</sup> declined to accept

sinuses.

<sup>\*</sup> From the Department of Radiology, Columbia University College of Physicians and Surgeons.

 $T_{\rm ABLE}\;I$  Review of the reported cases of residual thorotrast in the paramasal sinuses

Author	Year Reported	Sex	Age	Elapsed Time between Instillation of Thorotrast and Malignant Degeneration
Hofer <sup>6</sup>	1952	F	64	10 years
Gros, Fruhling, and Keiling <sup>5</sup>	1955	$\mathbf{M}$	36	15 years
Looney and Colodzin <sup>8</sup>	1956	Not	Not	Not stated
		stated	stated	
Kligerman, Lattes and Rankow <sup>7</sup>	1960	F	70	15 years
Kligerman, Lattes and Rankow <sup>7</sup>	1960	F	32	18 years
Kligerman, Lattes and Rankow <sup>7</sup>	1960	$\mathbf{M}$	39	21 years
Kligerman, Lattes and Rankow <sup>7</sup>	1960	$\mathbf{M}$	70	10 years
Present Report		$\mathbf{M}$	44	10 years
Present Report		$\mathbf{M}$	45	15 years
Present Report		F	53	No malignancy discovered at time of surgery—13 years post instillation

thorotrast for intravenous use, but deferred condemnatory action on its use via other routes. Since that time, numerous clinical and experimental studies on its local and systemic effects have been conducted and the literature is replete with instances of its delayed carcinogenic effects.<sup>2,12,14</sup> The existing criticism, however, has been mainly based on animal experiments<sup>1,4,17</sup> and its effects on man after interstitial extravasation<sup>14</sup> or intravenous injection which resulted in permanent retention of the drug by the reticuloendothelial system rather than through local contact.<sup>9</sup>

### REVIEW OF THE LITERATURE

A review of the medical literature has disclosed 7 cases in which a carcinoma developed at the site of residual thorotrast years after its intrasinusal injection, 4 from the Columbia-Presbyterian Medical Center. Recently, 3 more cases have come to our attention, 2 of which exhibited carcinoma of the maxillary antrum. This makes a total of 7 cases discovered in the Columbia-Presbyterian Medical Center in a 6 year period (Table 1).

Hofer, in 1952,6 published an instance of a squamous cell carcinoma developing in the maxillary antrum of a 64 year old woman 10 years after the intrasinusal injection of thorotrast. This was treated surgically and radioactivity was demonstrated in the specimen. Gros et al.5 in 1955, reported the occurrence of an epithelioma in the maxillary sinus of a 36 year old man 15 years after injection of thorotrast into the antrum. Radioautography of the opaque material showed radioactivity. Looney and Colodzin,8 in 1956, described one case of carcinoma of the maxillary sinus after local instillation of thorotrast. No follow-up was included in any of these reports. Kligerman, Lattes, and Rankow, in 1960, reported 4 cases from the Columbia-Presbyterian Medical Center where there was roentgenographic evidence of radiopaque collections within a maxillary sinus. All 4 patients gave histories of having had antral instillations of thorotrast for diagnostic purposes while under treatment for sinusitis 10, 15, 18 and 21 years prior to admission. All 4 patients were subjected to surgery and or radiation therapy and had histologically proven antral carcinoma with radioactivity detected in the specimen. Since the publication of their article, 3 more cases have come to our attention.

### REPORT OF CASES

Case I. MG (154-62-54), a 45 year old white male bookkeeper, complained of pain and

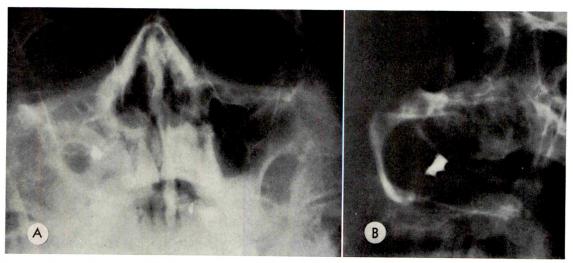


Fig. 1. Case 1. (A and B) Roentgenograms of paranasal sinuses showing radiopaque material centrally situated in a clouded right maxillary sinus. Note metallic homogeneous density, polyhedral in shape and irregular in contour.

tenderness of the right side of the mouth and cheek. Two right upper molars had been extracted 4 months before with subsequent development of an oroantral fistula. Roentgenograms at that time reportedly showed only soft tissue swelling. Because of lack of improvement and progressive loosening of the remaining right upper teeth, the patient sought further help.

At the time of hospital entry, the right cheek was swollen and slightly tender. Except for two loose incisors, all the right upper teeth were missing. The entire right hard and soft palate and alveolar ridge were covered by thick granulations. There was a fistula between the right gingivobuccal gutter and the right antrum. No neck lymph nodes were palpable. Roentgenographic examination of the paranasal sinuses revealed a soft tissue mass filling the right antrum and projecting into the right nasal cavity with associated destruction of the medial, inferior and anterolateral antral walls. The alveolar ridge was also invaded by the mass. These findings were felt to be compatible with a carcinoma of the maxillary antrum with extensive local involvement. In addition, an irregular foreign body of metallic density which measured roughly 4×6 mm. was described (Fig. 1, A and B).

A Caldwell-Luc procedure was performed and the right antrum was found to be replaced by friable neoplastic tissue. The biopsy was reported as carcinoma of the mucoepidermoid type. The patient was then treated by surgical excision of the right maxilla followed by application of a radium mold. The specimen was studied by means of spectrographic analysis and found to be compatible with thorium.

Case II. WB (137-30-55), a 44 year old white male, was first seen with a chief complaint of an unpleasant nasal discharge of 9 months' duration. The patient gave a history of seasonal allergic rhinitis and asthma for many years. Desensitization therapy had been ineffectual. He related that many years ago injections were made into his sinuses for study purposes. Three months prior to hospital admission, he developed numbness of the right side of his nose, cheek and upper lip. One month prior to admission, he noted bloody nasal discharge, followed by puffiness of the right lower lid and a mass over the upper right cheek along with obstruction of the tear ducts. There was no pain.

Physical examination revealed slight swelling of the right lower eyelid. A mass could be palpated along the inferior orbital rim extending along the bony floor of the orbit and downward over the anterior maxillary plate. There was an associated 2 mm. proptosis and anesthesia of the right cheek, medial aspect of the right side of the nose, upper lip and gums. All ocular movements were normal.

Roentgenograms demonstrated bony destruction of the walls of the right antrum and floor of the orbit. The right maxilla and orbital contents were resected and microscopic ex-

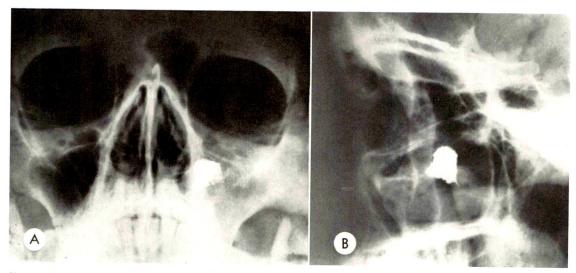


Fig. 2. Case III. (A and B) Roentgenograms showing diffuse clouding of the left antrum containing a single conglomerate of radiopaque material apposed to the medial wall. Note polyhedral shape and irregular contour.

amination showed a squamous cell epithelioma with direct extension into the optic nerve, pterygoid muscles, orbital fat, ethmoid and sphenoid sinuses. The patient received post-operative radiation therapy and subsequently had a radical neck dissection for metastases to the right submaxillary lymph nodes. Biopsy of a chest wall mass 2 years later at the level of the third and fourth left ribs posteriorly revealed metastatic squamous cell epithelioma. He then received betatron therapy to the chest wall and expired 7 months later.

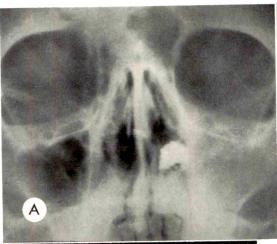
Case III. DG (156-16-80), a 53 year old white female, was first seen with a chief complaint of periodic headaches of 5 years' duration. These had been diagnosed as migraine and treated with ergotamine tartrate with no benefit. Because the headaches had become increasingly frequent, roentgenograms of the skull and sinuses were taken which revealed the presence of a radiopaque substance in the left maxillary antrum. At that time, she could not explain its presence, but on further questioning, she recalled that 13 years before she had been treated for "lingering colds" and that a liquid had been instilled into her sinuses. The only other intrasinusal medication consisted of nose drops (type unknown).

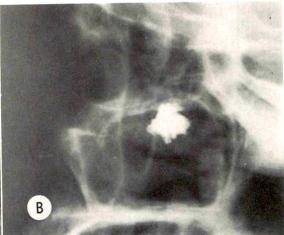
Review of the roentgenograms taken elsewhere disclosed diffuse clouding and the presence of a collection of radiopaque material within the left maxillary sinus (Fig. 2, A and B).

Re-examination here 9 months later revealed that the opaque material had changed both in shape and position. The mass now seemed more irregular in outline, somewhat smaller in size and had moved medially. It now appeared to be within an ethmoid sinus (Fig. 3, A, B and C).

The sinus was irrigated and radioactivity was demonstrated in the material obtained from the washings. Roentgenograms taken of the washings showed minute punctate radiopacities distributed throughout the debris.

A Caldwell-Luc procedure revealed thickened mucosa and a polypoid mass in the right antrum. The mass was removed and roentgenograms of the surgical specimen showed numerous tiny radiopaque particles. Pockets of pus were present which contained dirty brownish gray particles of the type found to be radioactive before the operation. In the region of the medial portion of the antrum, and partially eroding through the wall of an ethmoid sinus, a large chunk of this foreign matter was uncovered and removed. As the dissection proceeded, more of this material consisting of multiple dark brownish gray fragments with a putty-like consistency was removed. The largest of these fragments measured 8 mm. in length. The polypoid contents of the antrum consisted of several glistening pale pinkish tan fragments of tissue, the largest measuring 1.7 cm. in length. Microscopically, no in situ or invasive carcinoma was found. The edematous stroma showed fibrosis and scattered acute and chronic





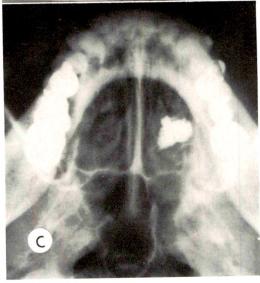


Fig. 3. Case III. (A, B and C) Roentgenograms made 9 months after Figure 2. Note change in shape of foreign body. The mass is slightly smaller and has migrated medially.

inflammatory cells. The tissue extracted from the ethmoid cells contained amorphous basophilic debris resembling those seen in the foreign material. The foreign material was submitted for study and exhibited radioactivity compatible with thorium. The final pathologic diagnosis was chronic sinusitis with foreign body in antrum.

### DISCUSSION

These case histories serve to strongly support the contention that the oncogenous effect of radioactive thorotrast is a real danger. Although thorotrast is reportedly not absorbed by mucous membranes, its carcinogenic effect can be the result of local irradiation. If residual thorotrast is recog-

nized, it should be removed before a neoplasm has had a chance to develop.

The appearance, similar in all cases, is that of a radiopaque body or bodies of metallic density lodged in one of the paranasal sinuses and usually associated with mucosal thickening and clouding of the cavity (Fig. 1–4, inclusive). The opacity may be composed of a single particle or multiple particles (Fig. 4, A and B). Most often, they are polyhedral in shape and irregular in outline. The size of the particles ranged from that of a pinpoint to 20 mm. in diameter. Larger amorphous masses may be seen with jagged contours which are collections or conglomerates of several smaller fragments. In cases where malignant

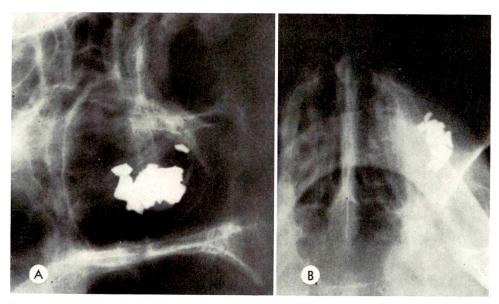


Fig. 4. Case 3 reported by Kligerman *et al.*<sup>7</sup> (A and B) Radiopaque mass in left antrum composed of an aggregate of numerous particles of metallic density. Note variation in size and shape of individual particles and jagged contours. (Previously unpublished roentgenograms.)

change had occurred, accompanying bone destruction and obliteration of the bony margins of the cavity were additional features which made the diagnosis even more certain. In a typical case, obliteration of the sinus cavity accompanied by destruction of its walls together with a retained metallic mass were telltale indications of malignant degeneration due to thorotrast.

Grossly, thorotrast appears as brownish black granular or sand-like particles. A roentgenogram of the specimen or washings will often reveal pinpoint metallic densities which represent the fragmented particles. Subsequent roentgenograms of the sinuses may show fragmentation, separation and change of shape of the remaining conglomerates and migration of some of the material into the adjacent sinus cavity, or lying separated in the same cavity. Moreover, diagnosis is strengthened if malignant change of the involved sinus is seen or suspected.

Histologically, thorotrast is suggested by the finding of coarse, highly refractile granules that are faintly basophilic and which may lie in a dense fibrous tissue stroma or may be largely concentrated within macrophages.<sup>14</sup> Clinically, the patient may be asymptomatic or have symptoms due to malignant degeneration or the inflammatory, fibrotic and granulomatous changes resulting from the foreign body response of the adjacent tissues. It is reasonable to assume, however, that after a long period of time, symptoms would become manifest and would ultimately result in disability.

### DIFFERENTIAL DIAGNOSIS

Included in the differential diagnosis would be metallic foreign bodies and retained lipiodol. Calcified blood clots, unerupted or eroding teeth, dentigerous cysts. rhinoliths and bone or calcium containing tumors such as osteomas may also be considered, but are usually easily differentiated because of their lesser density. Retention of metallic foreign bodies such as lead shot or shrapnel following gunshot wounds or fragments from accidental injuries and explosions can often be ruled out on the basis of history. In addition, thorotrast exhibits radioactivity which can be detected by external counting or by analysis of a specimen obtained by sinus washings. Lipiodol has a tendency to form globules as opposed to the more irregular polyhedral appearance of thorotrast collections. In addition, lipiodol is gradually absorbed at a rate of I cc. per year so that it would not remain unchanged in amount and configuration for the length of time reported in the majority of thorotrast cases (the longest was 2I years).

The penetration of fragments of dental fillings, teeth and dental roots into the maxillary sinus either fortuitously or during the course of an extraction is a frequent occurrence.16 Unerupted teeth may erode into the maxillary sinus or impinge on the antral floor. The latter may be associated with cvst formation and can be recognized by their characteristic configuration and calcific density.18 Rhinoliths may originate in the nose and go on to invade a paranasal sinus by pressure necrosis. Two types are recognized: exogenous, due to concretions about foreign bodies; and endogenous, due to concretions laid down about a nidus, such as blood clots, nasal secretions, encrusted teeth, desquamated epithelium, clumps of bacteria, and fragments of bone.22 Chemically, rhinoliths consist chiefly of calcium phosphate, magnesium phosphate, calcium carbonate, organic matter and water. They vary in size from that of a small pebble to a mass of 115 gm. On roentgen examination they appear as a dense, irregular, nonhomogeneous calcific or ossified mass which may have a nodular configuration or may be branching and corallike in appearance.<sup>13</sup>

### SUMMARY

- 1. Three additional cases of thorotrast retention within a paranasal sinus are added to the 7 previously reported in the literature.
- 2. Carcinoma of the antrum had developed in 2 of these cases approximately 10 years and 15 years after instillation, while the third case exhibited benign polypoid changes 13 years after instillation.
- 3. Its recognition within a sinus cavity is important, not merely from the standpoint of the removal of a foreign body, but from the proclivity of this substance to produce

necrosis and malignant change in tissue with which it remains in contact.

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### LAMINAGRAPHY OF THE EAR

### NORMAL ROENTGENOGRAPHIC ANATOMY

By GALDINO E. VALVASSORI, M.D. CHICAGO, ILLINOIS

THE examination of the small struc-THE examination of the tures of the ear which are contained in the petrous pyramids has always been a challenge to the radiologist. Multiple projections have been devised in order to better visualize these small structures, but there remains confusing superimposition of structures located in different planes upon the structures in question. The introduction of laminagraphy opened to the radiologist a new field of investigation, but the results obtained with the standard linear motion have been disappointing. The normally available 30 or 35 degree angular motion produces cuts too thick—over 2 mm.—and leaves confusing residuals of structures parallel to the direction of the obscuring movement. These two obstacles have been overcome by some of the modern laminagraphic units. The Massiot polytome allows a separating capacity or thickness of the cut as small as I mm, and a coefficient of distinctness about five times as great as the one obtained with a linear trajectory of the same angle. This is obtained by a complex and lengthy obscuring movement so as to spread the extraneous residuals over a greater area to the point that no discernible image is left.

The major categories of pathologic conditions involving the ear are congenital malformation, traumatic effects, inflammatory processes, degenerative processes and neoplasm. It is of great advantage to the otolaryngologist to know the nature and the extent of the pathologic processes in deciding whether or not corrective surgery can be attempted. The information obtained about the middle ear is of great interest because its structures cannot be visualized by direct examination, it is the most difficult area to be evaluated by the multiple clinical and laboratory tests and it is the area

most commonly involved by pathologic processes.

### METHOD

Three projections are used for the study of the ear—lateral, frontal, and Stenvers' projection. The axial study is rarely considered in lesions strictly limited to the ear but it is used routinely in processes involving the petrous pyramids from outside.

### LATERAL PROJECTION

The patient lies prone on the table with the side to be examined away from the table top. This facilitates the centering, particularly when the skull is asymmetric. The structures of the ear extend from 2 to 5 cm. from the outer surface. For orientation, the various portions of the ear are found in the following sections from the patient's skin: (1) external auditory canal—from 1.5 to 2.5 cm.; (2) middle ear (ossicles) from 2.5 to 3 cm.; (3) vestibule, most of the semicircular canals and the cochlea from 3 to 4 cm.; and (4) internal auditory canal from 4 to 5 cm.

### FRONTAL PROJECTION

The patient may lie either prone or supine. It is important to have the line running from the tragus to the external canthus perpendicular to the table top. All the ear structures are included in a 2 cm. thickness extending posteriorly from the anterior wall of the external auditory canal. From front to back the visualized structures are: cochlea, epitympanic recess, malleus, incus, middle ear cavity, external auditory canal, internal auditory canal, vestibule, oval window, and semicircular canals.

### STENVERS' PROJECTION

The patient lies prone with the head rotated to a 45 degree oblique angle, bringing

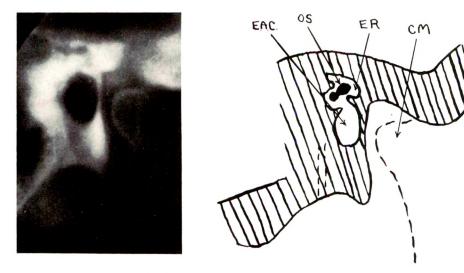


Fig. 1. Lateral laminagram and tracing of the normal ear at 2.4 cm. from the patient's skin. E.A.C.—external auditory canal; OS.—ossicles; E.R.—epitympanic recess; and C.M.—condyle of mandible.

the petrous pyramid under examination parallel to the table top. The head is flexed 12 degrees. The structures of the ear are included in a 2 cm. thickness extending posteriorly from the external auditory porus. From front to back the structures best seen are: external and middle ear cavities, round window, vestibule and semicircular canals, especially the posterior, cochlea and, finally the internal auditory porus. This projection is most useful for the study of the relation-

ship between the middle ear cavity and the carotid canal.

## ROENTGENOGRAPHIC ANATOMY LATERAL PROJECTION

The outer portion of the external auditory canal is well seen in sections between 1.5 and 2.4 cm. from the patient's skin.

Figure I shows a section obtained at 2.4 cm. from the patient's skin. The oval-shaped radiolucency of the external audi-



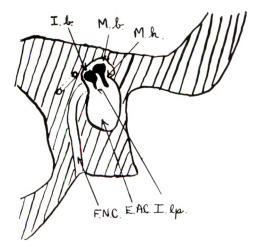


Fig. 2. Lateral laminagram and tracing of the normal ear at 2.6 cm. from the patient's skin. F.N.C.—facial nerve canal; E.A.C.—external auditory canal; M.b.—malleus body or head; M.h.—malleus handle; I.b.—incus body; and I.l.p.—incus long process.



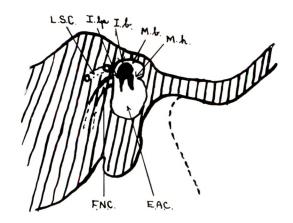


Fig. 3. Lateral laminagram and tracing of the normal ear at 2.7 cm. from the patient's skin. F.N.C.—facial nerve canal; E.A.C.—external auditory canal; L.S.C.—lateral semicircular canal; I.b.—incus body; I.l.p.—incus long process; M.b.—malleus body or head; and M.h.—malleus handle.

tory canal is sharply outlined. Superior to the canal the epitympanic recess is visible where the ossicles cast a dense shadow. The anterior and posterior tympanic spines separate the two cavities. The tegmen tympani forms the ceiling of the epitympanum. Anteriorly, the condyle of the mandible is well seen.

Figure 2 was made at 2.6 cm. from the skin. The external auditory canal, epitympanic recess, tegmen tympani and anterior tympanic spine are again seen. The malleus and incus are well demonstrated in this section. The anterior of the two ossicles is the

malleus; its shape is that of a club. The head of the club corresponds to the head of the malleus. The vertical process underneath it is the handle of the malleus. The posterior ossicle is the incus; its base extends downward with a fine tail, the long process. It is extremely important to realize that these two processes which point downward from the head of the malleus and body of the incus are seen in the same section and lie parallel to each other. Posteriorly, the vertical radiolucency of the distal portion of the facial nerve canal is well recognizable. Anteriorly, the condyle of the mandi-



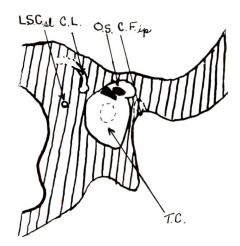


Fig. 4. Lateral laminagram and tracing of the normal ear at 2.8 cm. from the patient's skin. T.C.—tympanic cavity; L.S.C.s.l.—lateral semicircular canal, simple limb; C.L.—common limb; OS.—ossicles; and C.F.i.p.—condylar fossa, inner portion.



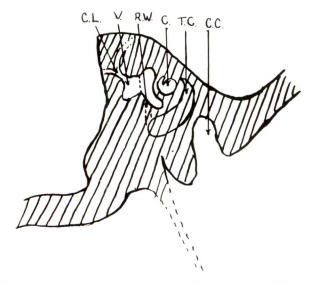


Fig. 5. Lateral laminagram and tracing of the normal ear at 3.2 cm. from the patient's skin. V.—vestibule; C.L.—common limb; R.W.—round window; C.—cochlea; T.C.—tympanic cavity; and C.C.—carotid canal.

ble is again seen. The sclerotic area posterior to the epitympanic recess is due to the bony capsule surrounding the horizontal or lateral semicircular canal.

The section shown in Figure 3 is 2.7 cm. from the skin and across the tympanic cavity. The ossicles are again visible in the epitympanic recess. The body of the incus is now better seen than the head of the malleus. The handle of the malleus and long process of the incus are also redemonstrated. The lateral semicircular canal is seen on the laminagram as two holes corresponding to the two limbs connected by a less

radiolucent band, the edge of the loop. Of the two limbs, the one located anteriorly and superiorly has a larger diameter which is due to the ampullar limb. The superior semicircular canal is faintly outlined below the arcuate eminence. Only the proximal portion of the vertical tract of the facial nerve canal is visible as it bends into the tympanic cavity. Anteriorly, the condyle of the mandible is again seen.

Figure 4 is a laminagram made at 2.8 cm. from the skin surface. The middle ear cavity shows a faint density within it, which is the promontory. Only the most

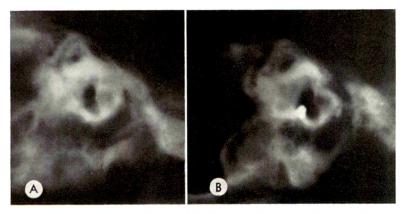


Fig. 6. Sections of a dry skull at the same level as Figure 5 for demonstration of round window. (A)

Before and (B) after introduction of a metallic plug into the round window.



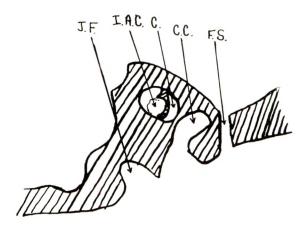


Fig. 7. Lateral laminagram and tracing of the normal ear at 3.8 cm. from the patient's skin. J.F.—jugular fossa; I.A.C.—internal auditory canal; C.—cochlea; C.C.—carotid canal; and F.S.—foramen spinosum.

medial part of the body of the incus remains in this section. The simple limb of the horizontal semicircular canal is seen as a round hole. Above it the arcuate band of radiolucency corresponds to the common limb or crus commune between the superior and posterior semicircular canals. Inferior to the lateral semicircular canal, the posterior semicircular canal casts a faint semicircular radiolucency with its simple limb. Anteriorly, the innermost portion of the condylar fossa is seen with the very fine petrotympanic fissure visible superior to it. The chorda tympani leaves the tympanic cavity through this fissure.

Figure 5, at 3.2 cm. from the skin sur-

face, shows the tympanic cavity as a crescentic radiolucency crossed by fine lines due to the wall of the pneumatic cells lining the cavity. The upper wall of the tympanic cavity is again formed by the tegmen tympani. The posterior extension of the tympanic cavity underneath the sclerotic capsule of the cochlea and vestibule is termed the sinus tympani or posterior sinus. The cochlea is sharply outlined. Posterior to the cochlea, the vestibule and the crus commune are clearly seen. The bifurcation of the simple limbs of the superior and posterior semicircular canals is clearly outlined. Anterior and inferior to the tympanic cavity is the inferior portion of the carotid

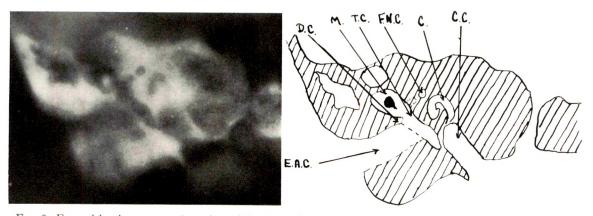


Fig. 8. Frontal laminagram and tracing of the normal ear at the level of the anterior wall of the external auditory canal. E.A.C.—external auditory canal; D.C.—drum crest; M.—malleus; T.C.—tympanic cavity; F.N.C.—facial nerve canal; C.—Cochlea; and C.C.—carotid canal.

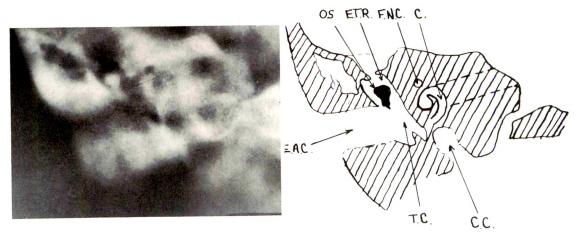


Fig. 9. Frontal laminagram and tracing of the normal ear at 2 mm. posterior to Figure 8. E.A.C.—external auditory canal; OS.—ossicles; E.T.R.—epitympanic recess; F.N.C.—facial nerve canal; C.—cochlea; T.C.—tympanic cavity; and C.C.—carotid canal.

canal. A depression on the posteroinferior aspect of the promontory represents the fossa of the cochlear or round window. Figgure 6, A and B is a corresponding laminagram of Figure 5. These sections were obtained in a dry skull before and after the introduction of a metallic plug into the round window in order to prove its location.

Figure 7, taken at 3.8 cm. from the skin surface, shows the internal auditory canal on end. Anterior to it a small portion of the

cochlea is still visible. The carotid canal is well outlined. The osseous process protruding downward from its inferior wall is the angular spine of the sphenoid. In front of it it is possible to recognize the foramen spinosum. Posteriorly, the jugular fossa is clearly outlined.

### FRONTAL PROJECTION

Laminagraphic sections are shown in a sequence from front to back.



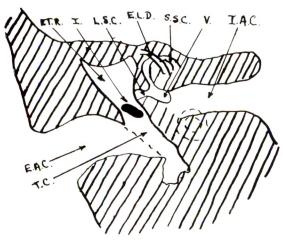


Fig. 10. Frontal laminagram and tracing of the normal ear at 2 mm. posterior to Figure 9. E.A.C.—external auditory canal; T.C.—tympanic cavity; E.T.R.—epitympanic recess; I.—incus; L.S.C.—lateral semicircular canal; E.L.D.—endolymphatic duct; S.S.C.—superior semicircular canal; V.—vestibule; and I.A.C.—internal auditory canal.

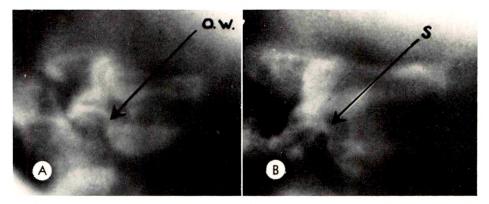


Fig. 11. Frontal laminagrams of the normal ear (A) at 2 mm. posterior to Figure 10 and (B) at the same level as A but in a different patient. O.W.—oval window and S.—stapes.

Figure 8 was obtained at the level of the anterior wall of the external auditory canal which, therefore, is not too well outlined in this section. Dividing the external auditory canal from the tympanic cavity, one notices an oblique bony crest which is the osseous ridge where the tympanic membrane is inserted. In the epitympanic recess the head of the malleus is seen as a round density. Medial to the tympanic cavity one of the turns of the cochlea is visualized. Below this the lower portion of the carotid canal is seen. Above the cochlea two holes are clearly outlined, both produced by the facial nerve canal. The facial nerve pierces the dura at the outer end of the internal auditory canal and enters the facial canal. It continues forward and slightly lateral-

ward to the hiatus of the facial canal where it makes a sharp bend (external genu). The two holes seen in Figure 8 are produced by the two limbs of the genu. The more medial hole is larger because it contains the geniculate ganglion. The facial canal continues posteriorly along the lateral wall of the vestibule above the oval window. It extends on the medial wall of the tympanic cavity to the junction of the medial and posterior wall where it bends downward to the stylomastoid foramen. The wall of the facial nerve canal where it runs along the medial wall of the tympanic cavity is extremely thin or partially absent. For this reason, this portion of the canal frequently is not recognizable in the laminagraphic sections.

Figure 9 was obtained 2 mm. posterior to

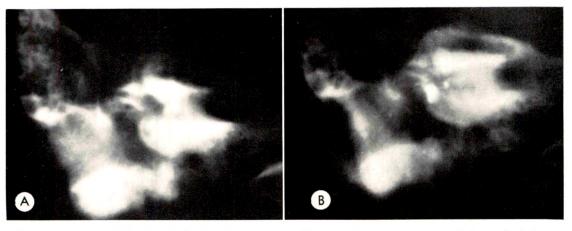


Fig. 12. Sections of the dry skull at the same level as Figure 11 for demonstration of the oval window.

(A) Before and (B) after the introduction of a metallic plug into the oval window.



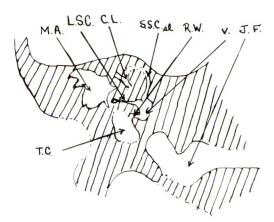


Fig. 13. Frontal laminagram and tracing of the normal ear at 3 mm. posterior to Figure 11A. T.C.—tympanic cavity; M.A.—mastoid antrum; L.S.C.—lateral semicircular canal; C.L.—common limb; S.S.C.s.l.—superior semicircular canal, simple limb; R.W.—round window; V.—vestibule; and J.F.—jugular fossa.

Figure 8. The external auditory canal, tympanic cavity, epitympanic recess, the tegmen tympani, the facial nerve canal, cochlea and the carotid canal are all seen again. The ossicles differ in appearance from those seen in Figure 8 in that the head of the malleus and the body of the incus produce a larger, slightly bilobular density. The handle of the malleus appears as a broad process pointing to the tympanic membrane. The internal auditory canal is faintly visualized in this section. At the extreme medial end the petro-occipital fissure is outlined.

Figure 10 runs 2 mm. posterior to Figure 9. The external and the internal auditory

canals are well seen. The superomedial lip of the osseous external auditory canal is quite prominent. This is termed the "spur" by the Danish investigators, Petersen and Stoksted. 11 Above the cochlea one sees the vestibule with the semicircular canals branching from it. The ampullar limbs of the horizontal and superior semicircular canals are visible. The faint arcuate radiolucency with lateral concavity, which extends from the vestibule to the superior aspect of the petrous ridge, crossing the superior semicircular canal, is produced by the endolymphatic duct. The tympanic cavity and epitympanic recess are well seen in this section. The ossicle, whose axis



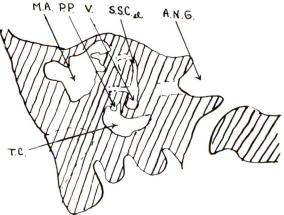


Fig. 14. Frontal laminagram and tracing of the normal ear at 2 mm. posterior to Figure 13. T.C.—tympanic cavity; M.A.—mastoid antrum; P.P.—pyramidal process; V.—vestibule; S.S.C.s.l.—superior semicircular canal, simple limb; and A.N.G.—acoustic nerve groove.

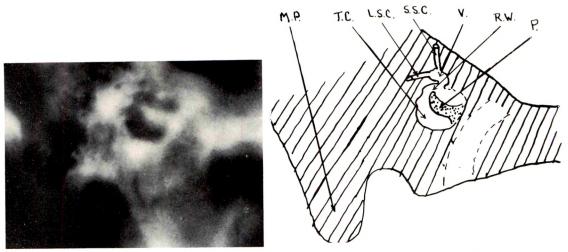


Fig. 15. Laminagram in Stenvers' projection and tracing of the normal ear at approximately 1 cm. posterior to the outer opening of the external auditory canal. M.P.—mastoid process; T.C.—tympanic cavity; L.S.C.—lateral semicircular canal; S.S.C.—superior semicircular canal; V.—vestibule; R.W.—round window; and P.—promontory.

points downward and medially, is formed by the lower body and base of the long process of the incus.

Figure 11, A and B was obtained 2 mm. posterior to Figure 10. A is a section from the same patient shown in the preceding laminagrams. Again the external auditory

canal, tympanic cavity, internal auditory canal, vestibule, ampullar limbs of the horizontal and superior semicircular canals are sharply outlined. The dense structure seen below the vestibule and the internal auditory canal is formed by the bony capsule surrounding the basal turn of the

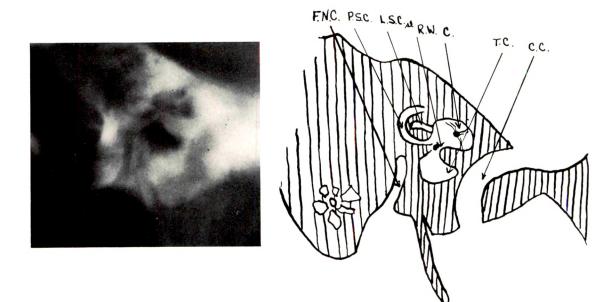


Fig. 16. Laminagram in Stenvers' projection and tracing of the normal ear at 2 mm. posterior to Figure 15. F.N.C.—facial nerve canal; P.S.C.—posterior semicircular canal; L.S.C.s.l.—lateral semicircular canal, simple limb; R.W.—round window; C.—cochlea; T.C.—tympanic cavity; C.C.—carotid canal.



Fig. 17. Section of a dry skull at the same level as Figure 16 for demonstration of the round window. A metallic plug is inserted into the round window.

cochlea. In the inferior portion of this section the jugular fossa is beginning to be seen. A dehiscence is detectable on the lateral wall of the vestibule just beneath the horizontal semicircular canal. This represents the oval window (vestibular window). The reason for this opening is that the footplate of the stapes which fits within it is extremely thin, certainly much thinner than the surrounding otic capsule, and lies in an oblique direction to the plane of the film. The medial wall of the tympanic cavity with the footplate of the stapes forms an angle open posteriorly of approximately 20

degrees with the sagittal mid-plane of the skull. By rotating the patient's head in the anteroposterior projection 20 degrees toward the side under examination, the footplate of the stapes becomes perpendicular to the plane of the laminagram and the crura parallel to it. They become, therefore, recognizable in approximately two-thirds of the cases. B shows the two crura of the stapes with the footplate seen as a very thin radiodensity bridging the oval (vestibular) window. This section was obtained with an angulation of 10 degrees. Figure 12, A and B, obtained in the dry skull at the same level as the section shown in Figure 11A before and after the introduction of a metallic plug into the oval window, proves that the structure demonstrated in the previous figure is actually the oval window.

In Figure 13, a laminagram taken 3 mm. posterior to Figure 11A, the external auditory canal lies anterior to this section and is not visible. The posterior part of the tympanic cavity is well seen. The dense bone forming the medial wall of this cavity underneath the posterior or simple limb of the horizontal semicircular canal represents the beginning of the basilar turn of the cochlea. The cleft seen in it is the fossa leading to the round window. The vestibule is clearly outlined. Besides the horizontal semicircular



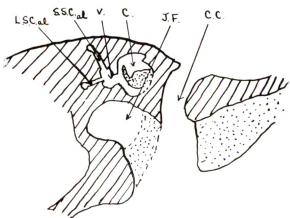
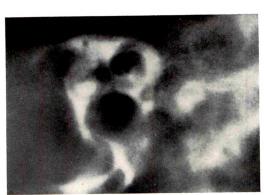


Fig. 18. Laminagram in Stenvers' projection and tracing of the normal ear at approximately the same level as Figure 16 but in a different patient. L.S.C.a.l.—lateral semicircular canal, ampullar limb; S.S.C.a.l.—superior semicircular canal, ampullar limb; V.—vestibule; C.—cochlea; J.F.—jugular fossa; and C.C.—carotid canal.



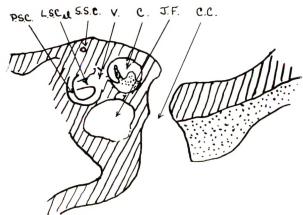


Fig. 19. Laminagram in Stenvers' projection and tracing of the normal ear at 2 mm. posterior to Figure 18. P.S.C.—posterior semicircular canal; L.S.C.s.l.—lateral semicircular canal, simple limb; S.S.C.—superior semicircular canal; V. vestibule; C.—cochlea; J.F.—jugular fossa; C.C.—carotid canal.

canal, the simple limb of the superior semicircular canal and the crus commune are demonstrated in this section. The mastoid antrum is seen in this section. In the inferior and medial part, the jugular fossa is seen. The bony wall dividing it from the tympanic cavity is quite thin.

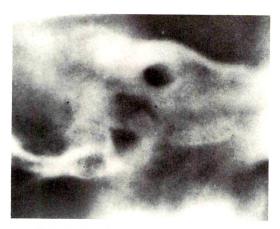
Figure 14, taken 2 mm. posterior to Figure 13, clearly shows the mastoid antrum. This section runs through the extreme posterior portion of the tympanic cavity which appears as a crescentic radiolucency with a bony spur, the pyramidal eminence, protruding into its superolateral portion. The basilar turn of the cochlea is seen here as the density forming the superomedial wall of the tympanic cavity. The vestibule is again seen. The simple limb of the horizontal semicircular canal is very faintly demonstrated; however, the simple limb of the superior semicircular canal is quite well visualized. The notch seen in the medial end of the petrous pyramid is the acoustic nerve groove. The large radiolucency present in the inferior and medial portion of this section represents the anterior portion of the jugular foramen.

### STENVERS' PROJECTION

Figures 15, 16 and 20 are laminagrams of one patient, while Figures 18 and 19 are of another patient.

Figure 15 was obtained 1 cm. posterior to the external opening of the external auditory canal. Laterally, the section cuts across the mastoid air cells. The middle ear cavity appears as a crescentic radiolucency whose superomedial wall is formed by the promontory. The cleft in the superior wall is due to the fossa for the round window. Above the promontory the radiolucent basal turn of the cochlea is seen. Adjacent to it, the vestibule with the lateral and superior semicircular canals branching from it is faintly visualized. The lower portion of the carotid canal is faintly seen just medial to the tympanic cavity.

In Figure 16, taken 2 mm. posterior to Figure 15, again the radiolucent band of the tympanic cavity is visualized, bordered superomedially by the promontory. The turns of the cochlea are seen lying above the promontory. Adjacent to these laterally, the vestibule is visualized with the entire posterior semicircular canal seen as the radiolucent ring extending laterally from it. The simple limb of the horizontal semicircular canal casts a linear band of radiolucency within the bony capsule circumscribed by the posterior semicircular canal. The carotid canal is seen in the medial part of this section as a curving band of radiolucency. The styloid process projects inferiorly. The distal tract of the facial



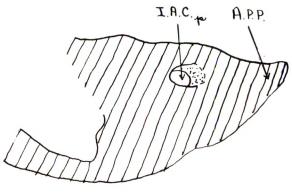


Fig. 20. Laminagram in Stenvers' projection and tracing of the normal ear at 8 mm. posterior to Figure 16. I.A.C.p.—internal auditory canal, porus; and A.P.P.—apex petrous pyramid.

nerve canal is outlined posterolaterally to it. The mastoid antrum is seen in the superolateral portion of this section. The fossa for the round window is clearly recognizable at the superior end of the tympanic cavity. In Figure 17, a laminagram made of a dry skull at approximately the same level as Figure 16, a metallic plug has been inserted into the round window to prove its location.

Figure 18 was taken at approximately the same level as Figure 16 but in a different patient. The vestibule is well seen and is divided into the superior or elliptical recess and into the inferior or spherical recesses by a bony ridge, the vestibular crest. The superior and horizontal semicircular canals are well seen. The cochlea is visible just medial to the vestibule. The turns of the cochlea are divided by the lamina spiralis. Inferiorly, the jugular fossa is represented as a large oval radiolucency. In the inferolateral wall of this radiolucency one can see the terminal portion of the sigmoid sinus entering the jugular fossa as a band of radiolucency. The inner portion of the carotid canal is well outlined.

In Figure 19, obtained 2 mm. posterior to Figure 18, the jugular fossa, sigmoid groove and inner portion of the carotid canal again are visible. The turns of the cochlea are sharply outlined. Laterally is the vestibule with the entire posterior semicircular canal and the simple limb of the horizontal semicircular canal. The superior semicircular

canal appears as a small radiolucent hole beneath the arcuate eminence. Figure 20, a laminagram of the same patient shown in Figures 15 and 16 was taken 8 mm. posterior to Figure 16. This is a section across the posterior aspect of the petrous pyramid. The porus or internal opening of the internal auditory canal is sharply outlined and appears as a "C" open anteromedially because of the prominence of its posterior, inferior and superior lips. The petrous apex is completely outlined.

### SUMMARY

In the examination of the small structures of the ear, laminagraphy is the procedure of choice. As an aid to radiologists, laminagrams and a detailed description of the findings are presented.

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### LAMINAGRAPHY OF THE EAR\*

### PATHOLOGIC CONDITIONS

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THE standard roentgenographic technique, even in special projections, has always been of limited value in the recognition and evaluation of the pathologic conditions of the ear.

Laminagraphy, if performed with an apparatus which furnishes a sufficient thin cut and a high coefficient of distinctness, has made possible the study of the minute structures of the ear and the evaluation of their pathologic conditions. Of course, the knowledge of the normal roentgenographic anatomy is essential for this purpose.

This spectrum of the pathologic conditions involving the ear is very broad. In this report the pathologic conditions have been divided into 4 groups: congenital abnormalities, traumatic injuries, inflammatory processes, and neoplastic conditions. A few examples of the above categories will be shown in which the laminagraphic study contributed to the establishment of the diagnosis and aided the otolaryngologist in deciding whether surgery was indicated or not and which type of surgical procedure to perform.

### CONGENITAL ABNORMALITIES

The impossibility of a direct otoscopic examination in most of these conditions due to a complete or partial atresia of the external auditory canal makes the roentgenographic study more essential than in any other pathologic process. The abnormalities range from minor anomalies to the complete aplasia of the entire ear.

In order to perform successfully corrective surgery, the surgeon must know the following:

- 1. Degree and type of abnormality of the tympanic bone.
- 2. Structure of the bony septum closing laterally the middle ear cavity (the so-

called lamina of atresia) in cases of atresia of the external auditory canal (complete or incomplete, thick or thin).

- 3. Degree of development of the tympanic cavity.
  - 4. Condition of the ossicular chain.
- 5. Degree and localization of the pneumatization of the mastoid antrum and mastoid cells.
  - 6. Route of the facial nerve canal.
  - 7. Status of the labyrinthine windows.

### ILLUSTRATIVE CASES

Case I. This 4 year old female on physical examination showed gross deformity of the right pinna and occlusion of the external auditory canal about I cm. inside the meatus. The left ear was normal. Laminagrams (Fig. I, A and B) of the right ear showed complete agenesis of the external auditory canal. The middle ear was hypoplastic and closed laterally by a bony septum, the lamina of atresia. In the epitympanic recess the large, slightly lobulated, osseous structure represented a single amalgam of the ossicles. The inner ear appeared normal. The mastoid was not pneumatized.

Case 2. This 27 year old female on physical examination showed absence of the left pinna and occlusion of the left external auditory canal. The air conduction on the left was absent. The bone conduction was normal. The right ear was normal. A regular skull examination revealed a sclerotic, poorly developed left mastoid. Laminagrams (Fig. 2, A and B) showed complete absence of the left external auditory canal with a thick lamina of atresia closing the tympanic cavity laterally. The middle ear cavity was normal except for hypoplasia of the hypotympanic recess. The ossicles were normal and the inner ear was normal.

Case 3. This 20 year old female was deaf since birth. Physical examination revealed deformity of the pinnae and external auditory canals. A chest roentgenogram demonstrated

<sup>\*</sup> Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D.C., October 2-5, 1962.

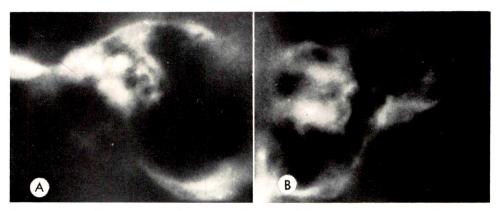


Fig. 1. Case 1. Atresia of the external auditory canal. (A) Lateral laminagram shows a single amalgam of the ossicles. (B) Frontal laminagram shows the absence of the external auditory canal and the lamina of atresia closing laterally the middle ear cavity.

several congenital abnormalities of the thoracic cage; a skull examination showed asymmetry between the right and left halves of the skull. The audiogram showed a marked decrease in the air conduction and a moderate reduction in the bone conduction—evidence of a severe conduction hearing deficit. Laminagrams (Fig. 3, A and B) revealed a severe dysplasia of the tympanic bones, as shown by the abnormal appearance of the external auditory canals, which had a peculiar funnel shape, narrowed medially. The canal, rather than lying in a horizontal plane, formed an angulation as it pointed medially and superiorly. For this reason, the outline of the outer portion of the external auditory canal was not recognizable in the lateral view. The ossicles, including the stapes, were recognizable. The incus was somewhat hypoplastic.

Case 4. This 20 year old female was complaining of left ear deafness. An audiogram revealed severe loss in the air conduction but normal bone conduction. Chest roentgenogram showed congenital anomalies of the ribs; a skull examination was negative. Laminagrams (Fig. 4, A and B) of the ear showed a normal external and middle ear cavity. The malleus and incus appeared intact except for a questionable shortening of the long process of the incus. The normal bony dehiscence of the oval window was not seen, suggesting a fusion of the foot plate of the stapes. At surgery, the malleus and incus appeared normal. There was fixation of a thick foot plate of the stapes into the oval window. The remainder of the stapes was absent except for a small lenticular process. A stapedectomy was performed. A vein graft and polyethylene strut were inserted. An audiogram 2 months

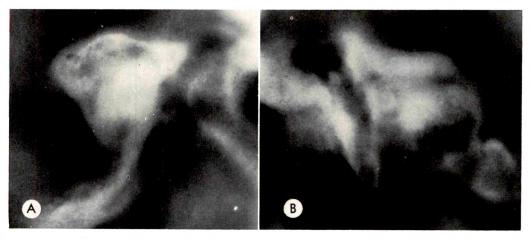


Fig. 2. Case 2. Atresia of the external auditory canal. (A) Lateral laminagram. (B) Frontal laminagram showing absence of the external auditory canal and a thick lamina of atresia.

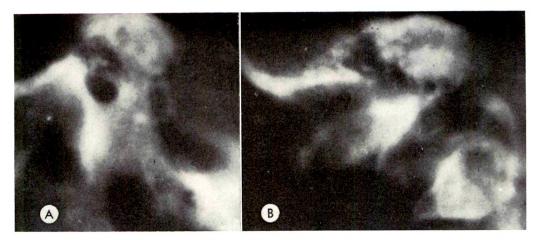


Fig. 3. Case 3. Dysplasia of the tympanic bone. (A) Lateral laminagram shows a narrowed external auditory canal. (B) Frontal laminagram shows the abnormal shape of the external auditory canal. Note the stapes.

after surgery showed a marked improvement with only slight loss in the air conduction.

### TRAUMATIC INJURIES

The mastoid, tympanic bone and petrous pyramids are unquestionably much more often involved in fractures following trauma to the skull than demonstrated by the standard roentgenographic examinations. The demonstration of a fracture is important from the therapeutic approach and from the medicolegal aspect.

The most common type of fracture involves the tympanic bone and very often extends to the epitympanic recess mostly to its very thin roof, the tegmen tympani. The

posterior wall of the tympanic cavity is also frequently the site of a fracture; in such a case, the vertical tract of the facial nerve canal is involved with a consequent neurologic symptomatology. Fractures of the bony capsule of the inner ear are not as common; according to Agazzi et al.,1 the posterior semicircular canal is the most frequently involved. Fractures and dislocations of the ossicles were demonstrated by Agazzi et al.1 and Brünner et al.2,3 The most common type of dislocation involves the incus whose fixation by ligaments is more loose than that of the malleus. More than one projection has to be used in all cases because the tiny fracture lines usually are de-

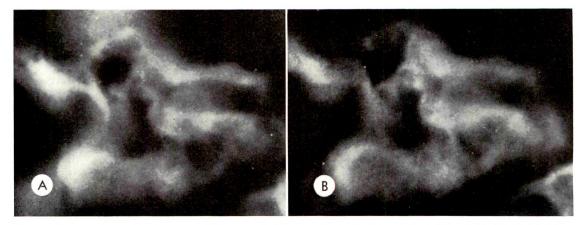


Fig. 4. Case 4. Congenital fusion of the foot plate of the stapes in the oval window. (A and B) Frontal laminagrams showing absence of the normal bony dehiscence of the oval window underneath the lateral semi-circular canal.

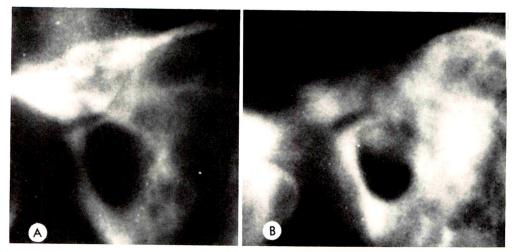


Fig. 5. Case 5. Fracture of the tympanic bone. (A and B) Lateral laminagrams showing the fracture extending from the condylar fossa into the epitympanic recess and to the tegmen tympani.

tectable in only one projection.

### ILLUSTRATIVE CASES

Case 5. This 8 year old female suffered a cranial concussion with scalp laceration. Neurologic examination was negative. Otoscopic examination revealed discoloration of the right tympanic membrane with several bullae. Skull roentgenograms were negative. Laminagrams (Fig. 5,  $\mathcal{A}$  and  $\mathcal{B}$ ) of the ear showed a definite fracture line running in an oblique direction from the condylar fossa upward, posteriorly and medially above the inner portion of the external auditory canal into the epitympanic

recess and to the tegmen tympany. There was no involvement of the ossicles.

Case 6. This 34 year old male was involved in a car accident and sustained fractures of several ribs. The patient suffered head concussion. Neurologic examinations revealed a peripheral paralysis of the right seventh cranial nerve. Roentgenograms of the skull demonstrated a fracture extending from the posterior portion of the right parietal bone into the temporal bone. Laminagrams (Fig. 6, A and B) showed a fracture extending from the posterior wall of the lateral part of the tympanic cavity,



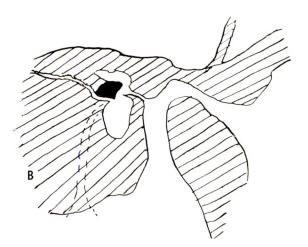


Fig. 6. Case 6. Fracture involving the facial nerve canal. (A) Lateral laminagram. (B) Tracing of A showing the fracture line extending from the posterior wall in the area where the facial nerve canal turns from the middle ear cavity into its vertical portion.

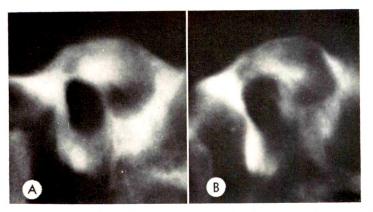


Fig. 7. Case 7. Cholesteatoma in the mastoid antrum. (A and B) Lateral laminagrams showing a very large mastoid antrum containing the cholesteatomatous mass outlined by the surrounding air.

in the area where the facial nerve canal turns from the middle ear cavity in its vertical portion. At surgery, the fracture was identified and several small bony fragments embedded in the facial nerve were removed with complete restoration of the nerve function.

### INFLAMMATORY PROCESSES

The recognition of an inflammatory process involving the ear by conventional roentgenography is based on the detection of mucosal thickening, destruction of the septa between the cells and reactive sclerosis of the mastoid. In a sclerotic mastoid, the radiolucency of the mastoid antrum is frequently erroneously interpreted as a destructive process.

Laminagraphy is of great help in the diagnosis and evaluation of the extension of

the inflammatory processes. These can be roughly divided into 3 main categories: simple otitis media, otitis media with osteitis of the walls and/or ossicles, and otitis media with cholesteatoma. In simple otitis media, one sees an abnormal haziness of the entire or part of the middle ear cavity. The differentiation between granulation tissue with osteitis and cholesteatoma is usually impossible. The density of a cholesteatomatous mass is identical to that of granulation tissue; the erosion and destruction of the surrounding bony structures are the same in the two conditions. The positive diagnosis of cholesteatoma can be made only when the mass is outlined by air around it or when the anturm, aditus and /or epitympanic recess becomes very enlarged. Fistulae between the middle ear

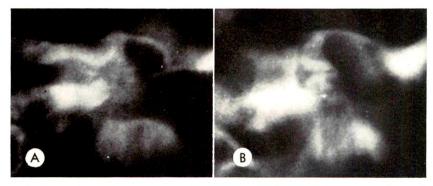


Fig. 8. Case 7. Cholesteatoma. (Same case as in Figure 7.) (A) Frontal laminagram shows the granulation tissue filling the tympanic cavity with almost complete destruction of the ossicles. (B) Frontal laminagram shows the cholesteatoma in the tremendously enlarged mastoid antrum.

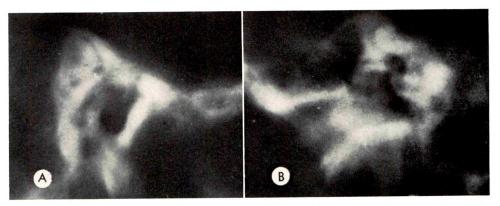


Fig. 9. Case 8. Cholesteatoma in the epitympanic recess. (A) Lateral laminagram shows the destruction of the long process of the incus. (B) Frontal laminagram shows a soft tissue density in the epitympanic recess. Note the bony crest in the external auditory canal.

cavity and the semicircular canals have been detected by Agazzi *et al.*, but again it is impossible to differentiate between a fistula and a focus of osteitis of the otic capsule.

The end results of an inflammatory process that can be demonstrated by laminagraphy are the abnormal relationship of the ossicles and the abnormal position of the tympanic membrane which often becomes adherent to the promontory.

### ILLUSTRATIVE CASES

Case 7. This 20 year old male had a history of bilateral otitis at the age of 4. Otoscopic examination revealed a perforation in the upper part of the right tympanic membrane with discharge. Air conduction was markedly decreased; the bone conduction was normal. Regular examination of the skull and mastoid revealed sclerosis of both mastoids and a large, wellcircumscribed area of destruction in the region of the mastoid antrum. Laminagrams (Fig. 7, A and B; and 8, A and B) of the right ear showed a tremendously enlarged mastoid antrum containing a well-defined mass, as outlined by the surrounding air. The destructive process extended to the aditus and epitympanic recess where fragments of the ossicles were detectable within the soft tissue mass obliterating the middle ear cavity. At surgery, a large cholesteatoma was found in the antrum; the middle ear was filled with granulation tissue. The malleus and body of the incus were necrotic and almost completely destroyed. The stapes was not involved and appeared intact.

Case 8. This 48 year old male, who underwent right radical mastoidectomy three years previously for chronic otitis media with cholesteatoma, was complaining of progressive hearing loss on the left with intermittent otorrhea for the past one year. The otoscopic examination of the left ear was difficult because of a bony exostosis in the external auditory canal but revealed attic perforation of the tympanic membrane. An audiogram showed severe loss in the air conduction and normal bone conduction. A regular examination of the skull and mastoids demonstrated diffuse sclerosis of the left mastoid. Laminagrams (Fig. 9, A and B) of the left ear showed narrowing of the external auditory canal due to a bony crest protruding from the anterior wall of the canal. There was bony erosion in the region of the aditus and epitympanic recess, as shown by the amputation of this spur. A soft tissue mass was visualized in this area. The long process of the incus was absent; otherwise, the ossicles appeared normal. At surgery, the cholesteatoma was found as described; it did not extend into the antrum. There was destruction of the long process of the incus.

Case 9. This 26 year old female was complaining of several episodes of left otitis and gradual loss of hearing on the left. Audiogram revealed a severe conduction type deafness. Laminagrams (Fig. 10, A and B) of the left ear showed complete absence of the long process of the incus and some deformity of the base of the body of the incus; otherwise, the middle ear

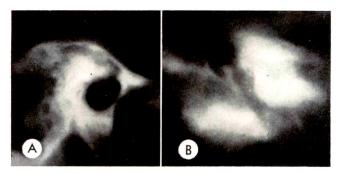


Fig. 10. Case 9. *Cholesteatoma in the tympanic cavity.* (A) Lateral laminagram shows the destruction of the long process of the incus. (B) Frontal laminagram shows an intact malleus.

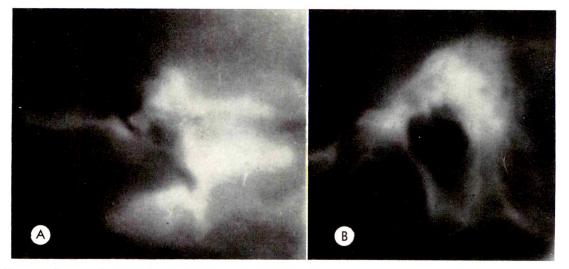


Fig. 11. Case 10. Cicatricial adhesions of the tympanic membrane to the promontory. (A) Frontal laminagram shows the tympanic membrane below the insertion of the malleus, crossing the tympanic cavity. Note the haziness of the lower portion of the middle ear cavity due to granulation tissue in it. (B) Lateral laminagram showing normal ossicles.

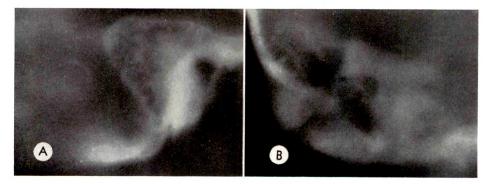


Fig. 12. Case 11. Osteoma of the external auditory canal. (A) Lateral laminagram. (B) Frontal laminagram showing an osseous mass obstructing almost completely the lateral portion of the external auditory canal.



Fig. 13. Case 12. Primary cholesteatoma. Frontal laminagram shows almost complete destruction of the right petrous pyramid with erosion of the cochlea. Note the large destruction in the basi-occiput.

appeared normal. At surgery, a cholesteatoma was found lining the medial surface of the tympanic membrane and extending anteriorly into the epitympanum. The long process of the incus was destroyed. The stapes was absent except for the foot plate, which was in place.

Case 10. This 55 year old female 7 months previously had discharge from the left ear lasting one week. Since then, the patient had continuous headaches on the left. Otoscopic examination revealed a left upper posterior perforation of the tympanic membrane. The audiogram showed a moderate reduction in air conduction. The clinical impression was that of cholesteatoma of the left ear with dural irritation. Laminagrams (Fig. 11, A and B) of the left ear showed obliteration of the mid-portion of the tympanic cavity by a soft tissue density extending to the promontory, typical of adhesions between the mid-portion of the tympanic membrane and the promontory. The ossicles and epitympanic recess were completely normal. At surgery, no cholesteatoma was found but, instead, there was granulation tissue in the middle ear cavity with adhesions of the tympanic membrane below the perforation to the promontory. A tympanoplasty was performed.

### NEOPLASTIC CONDITIONS

The classification of the neoplastic conditions involving the petrous pyramid and the ear is complicated by the frequent occurrence in this area of a group of lesions rarely seen elsewhere. We can divide the processes into 4 major groups:

1. Histologically benign tumors with a benign course. This group includes conditions usually involving the external auditory canal, such as osteomas, fibromas and lipomas.

- 2. Histologically benign tumors with a possible malignant clinical course because of the large destruction produced in the petrous pyramids and base of the skull by the growing tumor mass. This includes neurinomas (from the seventh to the twelfth cranial nerve), glomus jugulare tumors, epidermoids or primary cholesteatomas and chordomas.
- 3. Primary malignant processes, such as carcinomas or sarcomas, usually arising in the mastoid area.
- 4. Malignant tumors arising in structures adjacent to the petrous bone and involving it by direct extension, such as carcinomas of the nasopharynx and parotid gland.

Carcinomas, either primary or secondary, often have a typical appearance due to their tendency to infiltrate rather than to destroy the bone. If the carcinoma is infiltrating, the involved osseous structures have a typical mottled and moth-eaten appearance. If the carcinoma is purely destructive, then it is impossible to differentiate it from other processes.

Laminagrams in an axial projection are extremely useful in this group of conditions in order to evaluate the involvement of the structures adjacent to the petrous pyramids.

### ILLUSTRATIVE CASES

Case II. This 40 year old female had a 4 year history of decreased hearing of the left ear and occasional episodes of vertigo. Physical examination revealed a hard mass obstructing the external auditory canal on the left. An audiogram showed a definite loss of the air



Fig. 14. Case 12. *Primary cholesteatoma*. (Same case as in Figure 13.) Frontal laminagram shows destruction of most of the right internal auditory canal. Vestibule and semicircular canals appear not involved.



Fig. 15. Case 13. Glomus jugulare tumor. Frontal laminagram shows destruction of the right petrous pyramid.



Fig. 16. Case 13. Glomus jugulare tumor. (Same case as in Figure 15.) Axial laminagram shows a large destruction in the region of the right jugular fossa, which is markedly widened.

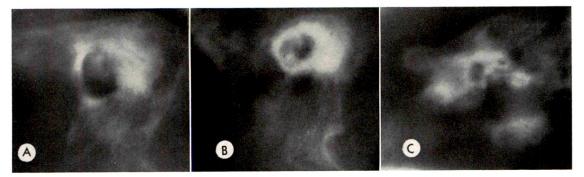


Fig. 17. Case 14. Carcinoma of the right parotid gland with extension to the base of the skull. (A) Lateral laminagram shows extensive moth-eaten destruction of the mastoid. (B) Lateral laminagram shows large destruction of the right petrous pyramid and floor of the middle cranial fossa. (C) Frontal laminagram shows destruction in the region of the jugular fossa involving the floor of the middle ear cavity.

conduction on the left. Laminagrams (Fig. 12, A and B) demonstrated a round, osseous mass in the external auditory canal protruding into the lumen from the superoposterior wall; otherwise, the left ear appeared normal. The diagnosis of osteoma was made and confirmed by surgery. A complete recovery of hearing was obtained.

Case 12. This 57 year old male had a 4 year history of progressive tinnitus and hearing loss bilaterally. The physical examination was negative except for partial paralysis of the right upper face. An audiogram showed severe bilateral nerve deafness. Laminagrams (Fig. 13 and 14) demonstrated a large destruction of the right petrous pyramid with erosion of the cochlea. There was destruction of the clivus with extension of the process to the left, as shown by the undermining of the left petrous apex. At surgery, a large subdural mass was found eroding the right petrous pyramid, basiocciput, basi-sphenoid, and extending to the apex of the left petrous pyramid. Histologically, the tumor was an epidermoid or primary cholesteatoma.

Case 13. This 72 year old female was seen for the first time in 1947 because of progressive hearing loss on the right and continuous tinnitus. Skull roentgenograms in 1947 revealed partial destruction of the right petrous apex. At surgery in 1947 a very vascularized mass was removed from the lower half of the tympanic cavity. Histologically, the lesion was interpreted at that time as hemangioma. On a more recent review of the histologic sections, the diagnosis was changed to glomus jugulare

tumor. The patient was in good condition until 1961 when she noticed weakness of the right side of the face. At physical examination, a Bell's palsy on the right was evident. Skull roentgenograms showed destruction of the apical portion of the right petrous bone. Laminagrams (Fig. 15 and 16) demonstrated a large destructive lesion in the region of the right jugular fossa involving the adjacent part of the occipital bone and the entire petrous pyramid. The tumor extended into the middle ear cavity with destruction of the floor.

Case 14. This 58 year old female had an adenocarcinoma of the parotid gland treated 2 years previously by right parotidectomy with resection of the facial nerve. The patient did well until 5 months prior to the current admission when she began complaining of a loud noise in the right ear with subsequent onset of double vision and unsteadiness in gait. Neurologic examination revealed decreased vision of the right eye, paralysis of the right lateral rectus, right Bell's paralysis and decreased hearing on the right. Skull roentgenograms showed a large destruction of the base of the skull involving the right petrous pyramid, sphenoid bone and right ramus of the mandible. Laminagrams (Fig. 17, A, B and C) showed destruction of the right petrous apex and motheaten involvement of the right mastoid, anterolateral aspect of the petrous bone, greater wing of the sphenoid and temporomandibular fossa. The middle ear was involved through destruction of its floor, but the ossicles were intact. Biopsy revealed metastatic adenocarcinoma and the patient was treated by radiation therapy.

#### SUMMARY

The importance of laminagraphy in evaluating pathologic conditions of the ear is stressed. These conditions are divided into 4 groups and illustrative examples of cases in which the procedure has been of benefit are given.

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The author wishes to thank Robert H. Pierce, senior medical student at the University of Chicago, for his cooperation in collecting the material and for preparing the explanatory sketches.

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## POLYDIRECTIONAL BODY SECTION ROENTGENOGRAPHY\*

## A NEW DIAGNOSTIC METHOD

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m B}^{
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m PHY,\ variously\ known\ as\ laminagra-}$ phy, planigraphy, stratigraphy and tomography, is now 40 years old. Its value in roentgen ray diagnosis, particularly in the diseases of the chest, is not questioned. The early body section devices and methods described by the pioneers, Bocage,2 Portes and Chaussé, 12 Pohl, 11 Vallebona, 17 Ziedses des Plantes,20 and Kieffer,6 contributed significantly to the development of laminagraphy. The roentgenograms produced by their techniques offered a decided diagnostic advantage within the limits of application of the method. The more universal acceptance of laminagraphy, however, has been inhibited by the limitations of the linear laminagraphy. One of the chief objections to the procedure is the presence of streaking linear parasite shadows which make laminagrams not only difficult to view but also reduce their diagnostic quality, particularly since these parasite shadows are encountered through all the laminagrams of all the levels sectioned.

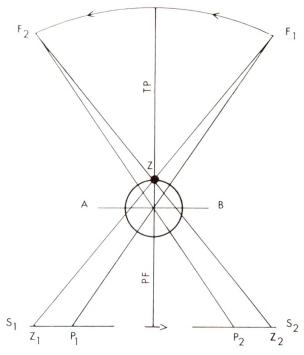
The history of laminagraphy contains accounts of many ingenious attempts to overcome the objectionable physical limitations due to linear obscuring movements. Additional obscuring movements, such as circles, squares, crosses, and Archimedean spirals were discussed by Bocage in the earliest descriptions of laminagraphy. Other types of pluridirectional laminagraphic techniques were reported by Portes and Chaussé, Pohl, and more completely, by Ziedses des Plantes. The history of the early phase of laminagraphy is covered well in a comprehensive article by Andrews. The interested reader is referred to this ar-

ticle for more complete details. The earliest attempt in this country to develop and apply compound tube movements to the principles of laminagraphy was made by Kieffer<sup>6</sup> who employed circular, spiral and sine-tube movements. This unit was made available commercially to American radiologists and it is undoubtedly familiar to many readers. Moore<sup>7</sup> reported the clinical advantages of this device.

One of the latest practical pluridirectional laminagraphic devices (now manufactured under the name, Polytome\*) was first introduced to radiologists at the Brussels Congress by Raymon Sans and Jean Porcher of Paris, France, in July, 1951. During the 10 years following its introduction, the use of this apparatus has increased significantly in Europe, where over 100 units are now in operation. Reports of the use of pluridirectional techniques by European users indicate a significant technical advantage of polydirectional obscuring movements (Gebauer, 4,5 Oliva and De Albertis,9 and Stieve13), and the clinical uses of this new method are increasing rapidly (Frey,3 Mundnich and Frey,8 Petersen and Stoksted, 10 Tarp, 14 Valvassori and Dabben, 18 and Wangermez et al. 19). The pluridirectional obscuring movement of the tube permits a relatively sharp focus upon a very thin tissue layer (approximately 1 mm. in thickness) and a film of the layer of high diagnostic quality. In an effort to determine whether or not there is a specific diagnostic advantage in confining the zone of interest to such a thin anatomic section, the first of these units was brought to the

<sup>\*</sup> Polytome-Massiot-Philips, Paris, France.

<sup>\*</sup> From the Department of Radiology of the Guthrie Clinic and Robert Packer Hospital, Sayre, Pennsylvania.



F1-F2: Target travel plane

A-B: Plane in focus

S: Film plane

Z: Point outside plane A-B

P1-P2: Point in plane A-B projected

to film

Z1-Z2: Displacement on the film of

Z, point outside plane of focus

TP: Target-Pivot distance

PF: Pivot-Film distance

Fig. 1. Simple diagram of the principle of body section roentgenography.

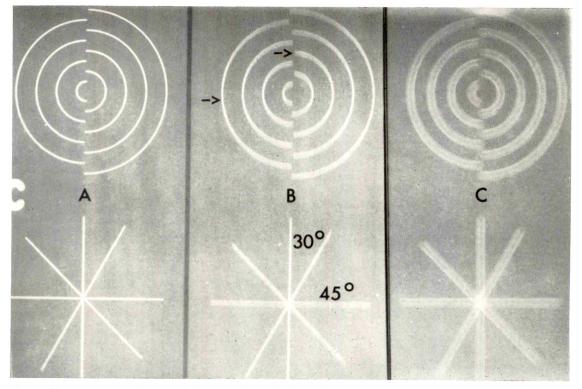


Fig. 2. Plane geometry phantom. (A) Section in focal plane. (B) Three mm. separation, linear movement. Note irregular blurring. (C) Hypocycloid movement also at 3 mm. separation showing greater uniform blurring.

United States in August, 1960, and installed at the Guthrie Clinic—Robert Packer Hospital. We wish to present the results of our preliminary work.

## THEORETIC CONSIDERATIONS

Laminagraphy is a special technique to show in detail images of structures lying in a predetermined plane of tissue, while blurring or eliminating detail in images of structures in other planes. The achievement of this principle depends upon the simultaneous movement in opposite directions of the roentgen ray source and the film during exposure.

A simple geometric example is seen in Figure 1. When the target travels from F1 to F2, the film is moved in the opposite direction from S1 to S2. During this maneuver, the shadows of all points in plane A-B remain stationary on the film; a correct image of plane A-B will, therefore, be projected. Shadows of points, such as Z, outside the plane A-B will have a relative displacement, Z1 to Z2, and be blurred or effaced. The blurring is less effective for points nearer the plane A-B than for points farther away from the plane of focus. Thus, the fact that the blurring is progressive rather than absolute accounts for the unsharpness inherent in all sectional roentgenography.

The diagnostic quality of a laminagram depends upon the usual factors governing photographic quality plus the technical properties inherent to the section device. These latter factors control the blurring or obscuring capabilities of the laminagraphic unit. The length of tube travel (the amplitude) governs the extent of blurring. Amplitude is often referred to as the angle of section. A greater amplitude produces a greater blurring effect and, conversely, a lesser amplitude results in a decreased blurring effect. The effective thickness or depth of focus of the investigated layer is also primarily affected by the amplitude—the longer the tube travel, the thinner the section. The distance from the roentgen ray source to the point of focus (the targetpivot distance) and the pivot-film distance can also be changed to affect the thickness of the investigated layer but in practice this is quite difficult to do on the average laminagraphic device. Images of good quality also depend upon small focal spot size, proper film and screen thickness, rigidity and smoothness of operation of the laminagraphic unit, a minimum of secondary radiation, proper exposure factors, complete immobilization of the patient and standard mode of film development.

## THE OBSCURING MOVEMENTS

The length and direction of tube travel (the obscuring movement) determines the effectiveness of the effacement of elements of the object outside the plane of focus. The length of tube travel governs the thickness of the tissue layer examined but it is the direction of tube travel which primarily controls the quality and completeness of the obscuring effect. When the tube movement involves a unidirectional or a linear or socalled rectilinear motion, the shadows of objects whose long axis is parallel to the long axis of the obscuring movement are not completely blurred or effaced but are elongated (Fig. 2B). It is this phenomenon which leads to the objectionable streaking on laminagrams made with linear obscuring movements. The images of elements perpendicular to the direction of the tube trajectory are completely effaced. It is this fact which accounts for the complete blurring of the ribs and bronchovascular markings on a conventional linear laminagram of the chest. It also accounts for the residual streaking of bronchovascular markings which are longitudinal on the laminagrams, and for the streaking over the longitudinal structures of the thoracic spine and sternum. Theoretically, therefore, the ideal blurring effect results when the obscuring ray arises from an infinite number of points and strikes the object from infinite directions. Such an ideal pluridirectional obscuring movement is closely met in the present device. By virtue of its compound movement, the obscuring beam effectively arises from

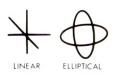






Fig. 3. The four obscuring movements: linear, any direction; elliptical, longitudinal and transverse; circular, o°-10°, 29° and 36°; and hypocycloid.

multiple directions so that no portion of the object is continuously parallel to the roentgen ray beam, with the result that undesirable parasite shadows are virtually eliminated. The blurring effect, therefore, is uniform throughout the entire laminagram (Fig. 2C) and is the same for objects of variable shapes and sizes.

### THE POLYTOME

The Polytome has four obscuring movements (Fig. 3) with a wide selection of amplitudes or angles (see Table 1). This wide variety of obscuring movements, angle of section and separating capacity provides a very versatile body section device. In many instances, a precise section characteristic may be chosen for an individual examination. The hypocycloid movement is unique to this device; its long tube travel—451 cm. with a wide angle of 48°—results in a very thin section (approximately 1 mm. in thickness) completely devoid of parasite shadows and with minimum unsharpness. The smoothness of mechanical operation, the heavy base, the small focal spot, the circular Bucky movement and other qualities also have been favorably considered in the design of the unit. The laminagrams made with all techniques are of high diagnostic quality. The pluridirectional movements, initially provided on this device, permitted examination of only very thin sections (1.0 mm. to 2.3 mm.). For curved parts such as the sternum, laminagraphy of thin sections can be a disadvantage. A recent attachment, however, provides for circular movements of 0° to 10°, and this makes an examination of a very thick section possible.

### CLINICAL APPLICATIONS

The present device has now been in continuous operation for 26 months and except for an initial breaking-in period of approximately 2 months, the laminagrams produced at the hands of different staff technicians have been of excellent diagnostic quality and have provided diagnostic advantages which had not been available previously. Polydirectional laminagraphy lends itself most advantageously to application in the skeletal system, the skull being an outstanding example. Figure 4 shows longitudinal sections through the odontoid process of 4 normal individuals. These sections and all subsequent laminagrams were made with the hypocycloid movement, unless otherwise noted. In these sections from normal individuals, attention is drawn to the angulation of the odontoid from the vertical axis. Similar angulation has been noticed repeatedly on laminagrams of other normal individuals with no history of trauma. Hence, this condition may be looked upon as a normal variation, perhaps better called the "pisa odontoid."

The base of the skull, particularly in axial section, can be very well visualized by this method. As an example, Figure 5, A, B and C shows a section from a patient who had clinical signs of malignant invasion of the fifth nerve, and the problem presented to us by the neurologist was to de-

TABLE I

	Angle of Cut (degrees)	Length of Trajectory (cm.)	Thickness of Cut (mm.)			
Linear	10-60					
	29	56	2.3			
	36	69	1.8			
	40	77	1.6			
	48	92	1.3			
	60	115	Ι.Ο			
Circular	29	176	2.3			
	36	217	1.8			
Elliptical	40	186	1.6			
Hypocycloid	48	45 I	Ι.Ο			

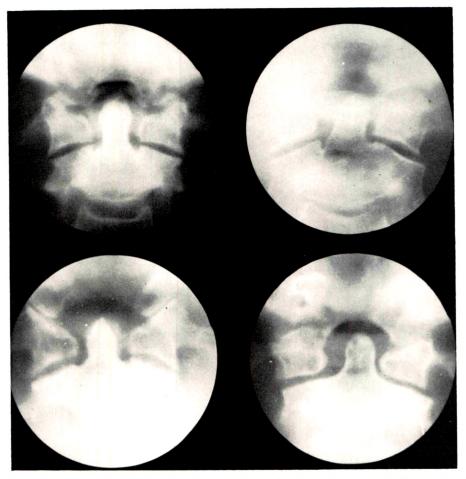


Fig. 4. Sagittal sections through the odontoid process of 4 normal patients employing the hypocycloid movement. Note uniform blurring and absence of "parasite shadows."

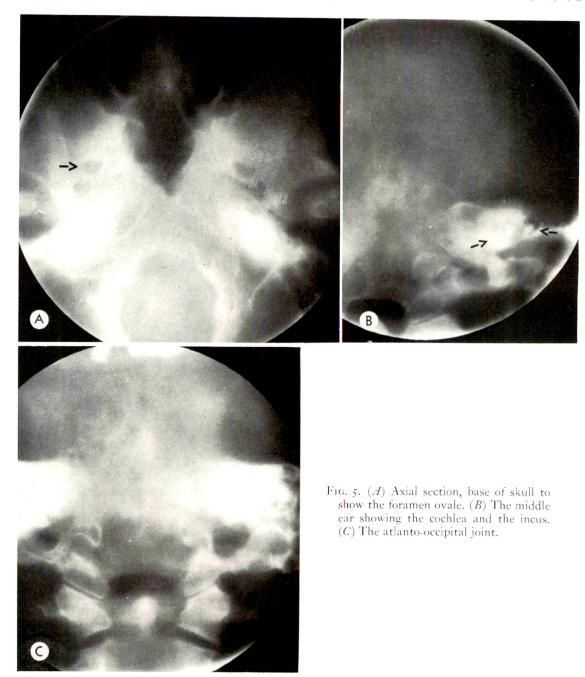
termine whether there was osseous invasion of the foramen ovale on the right side. The excellent visualization of this structure permitted a normal impression with a greater degree of certainty than could be attained from the more difficult evaluation of the conventional plain roentgenograms.

Very satisfactory visualization of the sella turcica is obtainable using sagittal and anteroposterior sections. In some instances it has been possible to detect erosion of one clinoid process. The sagittal views of the skull also have provided excellent visualization of the temporal bone, paranasal sinuses and, in particular, the middle ear (Fig. 5B). The detail and accuracy with which the normal and pathologic changes of the

middle ear can be visualized by this technique have been shown by Mundnich and Frey<sup>8</sup> and more recently by Valvassori and Dabben.<sup>18</sup> The atlanto-occipital joint (Fig. 5C) is also very well visualized in the sagittal section.

The mastoids (Fig. 6) lend themselves well to careful scrutiny in multiple planes. Consequently, the detection of cholesteatomata is relatively simple by this means. The paranasal sinuses are clearly visualized in axial (Fig. 7) and frontal section (Fig. 8).

Joint and long bone study by the pluridirectional techniques also increases the yield of information obtainable from roentgen-ray methods. The multiple directions of the trabeculae of the long bones produce



many parasite shadows on laminagrams made with a simple linear obscuring movement whether they be made parallel to the long axis of the shaft of the bone or perpendicular to it. This objectionable streaking actually obscures pathologic changes in some instances. With the polydirectional technique and its capability to make a very

thin section through any level of a long bone, sections are provided having a very distinct diagnostic advantage. We are seeing repeated instances where pathologic changes within bone have been visualized by this laminagraphic technique which are not detectable by any conventional roentgenographic technique available to us. Fig-

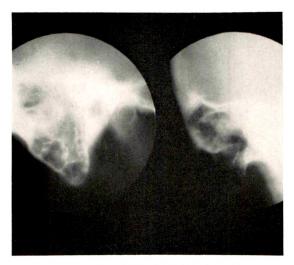


Fig. 6. The right mastoid in lateral and frontal section.

ure 9, A and B shows sections through some peripheral joints; Figure 10 the temporomandibular joint, closed and open. Sections of the temporomandibular joint can also be made in the anteroposterior or axial plane. The sternoclavicular joint also lends itself readily to examination by this technique (Fig. 11). The cervical spine (Fig. 12) lends itself well to examination with laminagraphy in the anteroposterior, lateral and oblique sections. Laminagrams were

sent to us from Dr. Ratgen, Aarhus, Denmark, showing sagittal sections of the cervical spine during the performance of air myelography. On these laminagrams the mass of the cord was outlined very well and even the cervical roots could be visualized as they emerged from the spinal cord.

The levels of the thoracic spine, which have continuously presented technical problems (e.g., the upper 5 thoracic vertebrae), are well visualized on polydirectional laminagrams. For the first time it is possible to see the spines of the thoracic vertebrae very clearly. The lumbosacral spine and particularly the posterior elements (Fig. 13) are visualized clearly as is the pelvis and, more particularly, the sacrum and coccyx.

The rather striking advantage of using a thin section for skeletal system study is not as rewarding when applied to the lung and other soft tissue structures where thicker sections and a unidirectional technique are preferred. In those instances where previously it has been helpful to section soft tissues (the chest, the kidneys with nephrotomography, etc.), the conventional linear movement still seems to be more satisfactory and more diagnostic than are the thinner sections with the polydirectional

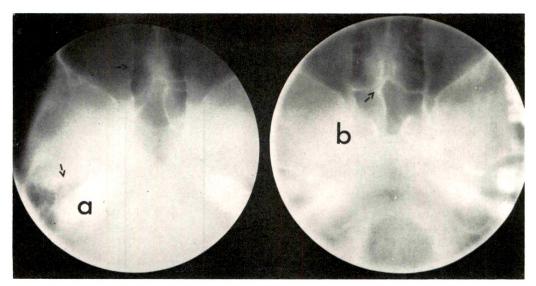


Fig. 7. Axial view, ethmoid and sphenoid sinuses. Note (a) fortuitous visualization of the incus and malleus and (b) the demonstration of an ethmoid-sphenoid canal.

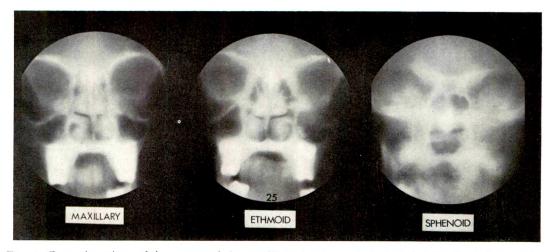


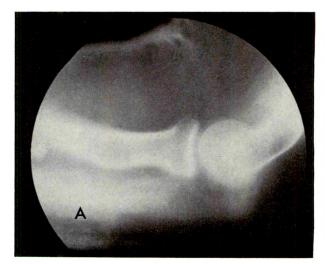
Fig. 8. Coronal sections of the paranasal sinuses. This view is particularly helpful in detecting maxillofacial fractures and osseous invasion from paranasal malignancy.

device. In a few instances, however, such as in Case IV, below, it has been helpful to take pluridirectional sections of a small area of a soft tissue organ.

Approximately 400 patients have been examined to date and a very decided diagnostic advantage has been noted in most of the cases studied. A few illustrative examples are presented.

## ILLUSTRATIVE CASES

Case I. A 60 year old white man presented himself with a history of pain in the left knee for a period of one year. The patient had been seen by his doctor who had administered weekly injections of a cortisone preparation which resulted only in temporary pain relief. No cultures and no roentgenograms of the involved knee were made. On admission plain anteroposterior roentgenograms were taken of both knees (Fig. 14, A and B) and a lateral roentgenogram of the left knee (Fig. 14C). The narrowing of the knee joint space was suggestive of tuberculosis, but no definite bone destruction could be identified on these films. For this reason, multiple laminagrams were made through the depth of the left knee in both the anteroposterior and lateral planes. Seven areas of bone destruction were demonstrated readily in both the femur



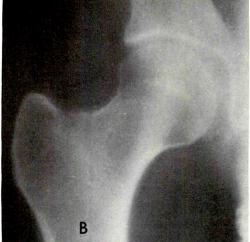


Fig. 9. (A) Section of radial head through a plaster cast. (B) Frontal mid-plane section of right hip.

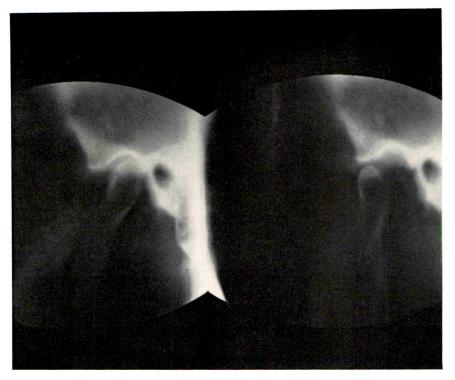


Fig. 10. Temporomandibular joint, closed and open views.

and tibia (Fig. 15, A, B and C); smear and culture of the aspirated fluid were positive for tuberculosis.

CASE II. A 78 year old white man experienced acute pain in his neck radiating down the left arm. The pain occurred suddenly as he turned his head significantly while driving his car. Plain roentgenograms (Fig. 16, A and B) in an anteroposterior and lateral plane demonstrated only degenerative arthritic changes of the cervical spine; no specific areas of bone destruction were identified. Because of the localized pain and the localized root radiation, laminagrams were made with the hypocycloid movement in anteroposterior and lateral planes. These demonstrated multiple small punched-out lesions of the fifth and sixth cervical vertebrae (Fig. 16C). One cyst had apparently ruptured through the superolateral cortex of the body of the sixth cervical vertebra, leaving a loose fragment of bone which at operation was seen to compromise the root at this level. The pathologic report indicated either benign fibrous dysplasia or simple degeneration cysts. The patient is still asymptomatic 2 years following operation.

CASE III. A 36 year old truck driver was ad-

mitted with a history of atypical catching-type pain in the lumbar area. He had previously been studied in two other institutions with no specific diagnosis and only palliative treatment was recommended. The initial plain roentgenograms (Fig. 17 $\mathcal{A}$ ) demonstrated some narrowing of the apophyseal joint of the third lumbar vertebra on the left side with sclerosis of the adjacent articular margins. Laminagrams (Fig. 17B)

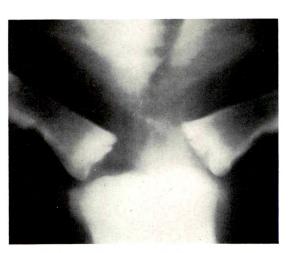


Fig. 11. Normal sternoclavicular joints.

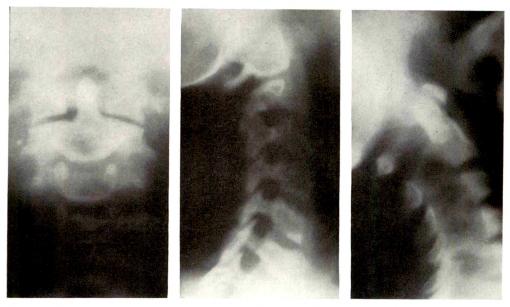


Fig. 12. Anteroposterior, lateral, and oblique sections of the cervical spine.

demonstrated a fusion defect of the inferior facet of the third lumbar vertebra which was considered to be congenital in nature. Because of the pain and degenerative changes of the joint as seen on the roentgenograms, the fragment was excised. The patient is virtually asymptomatic 15 months following operation.

Case IV. The patient was a 50 year old white male molder from a nearby foundry in which

there is a high incidence of silicosis and pulmonary malignancy. A small stellate shadow, noted on the annual survey roentgenograms (Fig. 18A), could not be definitely identified in the roentgenograms from previous examinations. Conventional linear laminagrams (Fig. 18B) established the fact that there was a density in this area but, again, there was insufficient detail to render a reasonable diagnosis. For this reason additional polydirectional

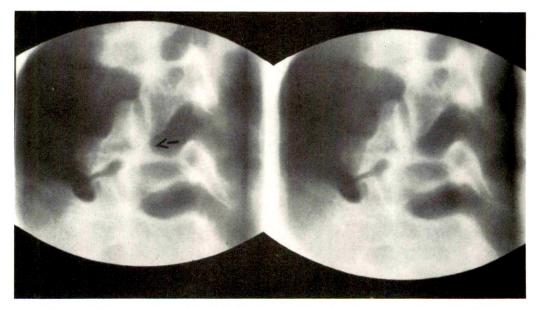


Fig. 13. Oblique sections of the fifth lumbar vertebra showing the pars interarticularis.

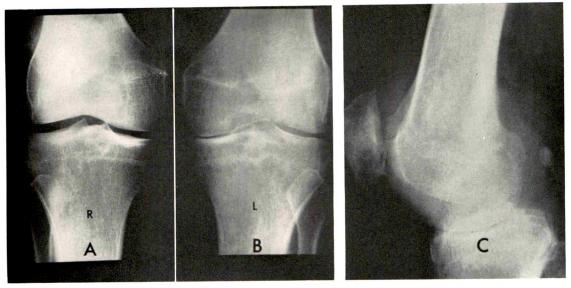


Fig. 14. Case I. (A and B) Plain roentgenograms of both knees and (C) a lateral view of the involved left knee.

laminagrams were made through just this area (Fig. 18C). These showed a densely calcified central nidus and the thickened wall of a small granuloma with peribronchial infiltration extending toward the hilus. Because of these rather characteristic features, the lesion was considered to be a primary type tuberculosis; retrospective critical review of previous roentgenograms indicated that it was there but fortuitously obscured by the ribs and the tip of the scapula on all other roentgenograms.

Case v. A 61 year old white man was admitted to the Ear, Nose and Throat Service with acute swelling of the left side of the face of 1 week's duration. Conventional anteroposterior erect roentgenograms of the sinuses were interpreted by the Service to show a fluid level (Fig. 19A) suggesting acute left maxillary sinusitis. The patient was scheduled for operative washing of this antrum. The appearance of an osseous septum in the inferior portion of this sinus (Fig. 19B) indicated that further lamina-

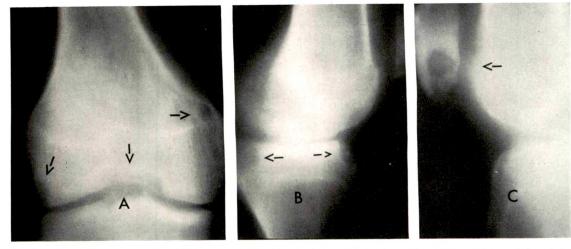


Fig. 15. Case I. (A) Anteroposterior section demonstrating a tuberculous abscess in each condyle of the femur and a large area of destruction in the intercondylar fossa. (B) Mid-plane lateral sections disclosed two abscesses in the tibia, each with a small sequestrum. (C) A large area of destruction in the patella. An abscess, not shown on other studies, in the femur opposite the patella was also demonstrated.

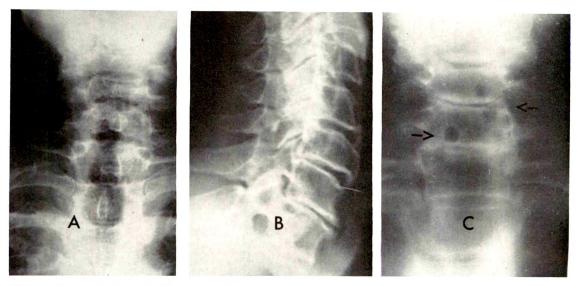


Fig. 16. Case II. (A and B) Conventional cervical spine roentgenograms showing moderate osteoarthritic changes. (C) Polydirectional laminagram in anteroposterior section showing punched out lesions of the fifth and sixth cervical vertebrae.

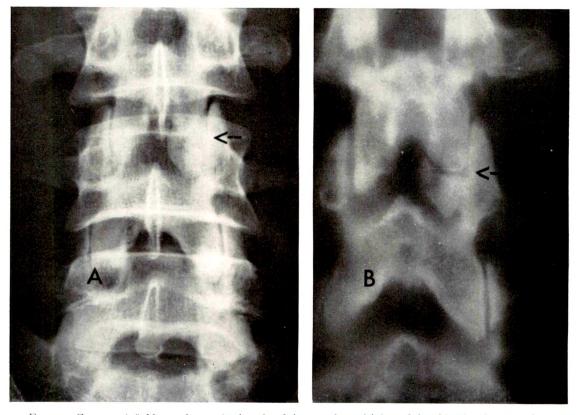


Fig. 17. Case III. (A) Narrowing and sclerosis of the apophyseal joint of the third lumbar vertebra did not reflect the unfused facet seen on the laminagram (B).

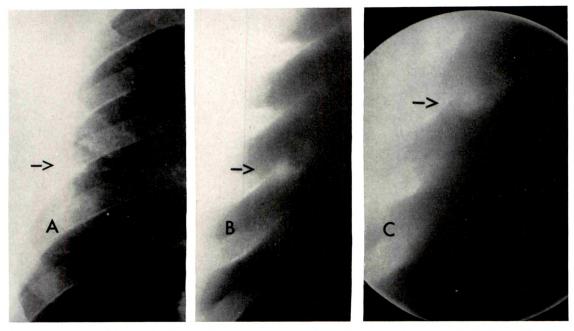


Fig. 18. Case IV. A small peripheral density is seen on the plain roentgenogram (A), confirmed but not identified on the conventional linear laminagram (B) and clearly identified as a calcified granuloma on the polydirectional laminagram (C).

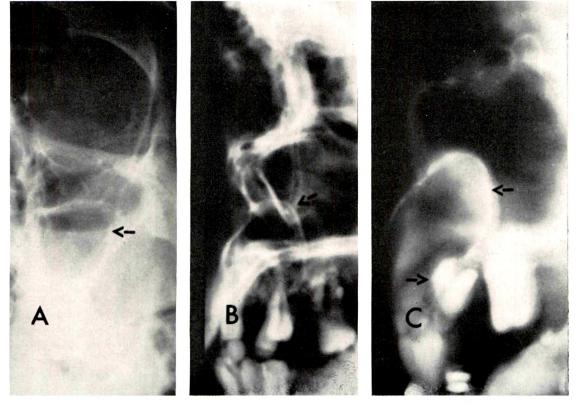
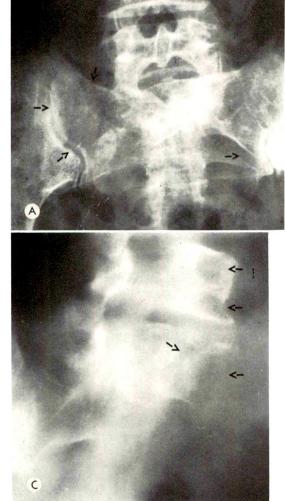


Fig. 19. Case v. Conventional anteroposterior roentgenogram (A) suggests antral sinusitis, but lateral roentgenogram (B) demonstrates bony septum which on laminagram (C) is seen to be a deciduous cyst.



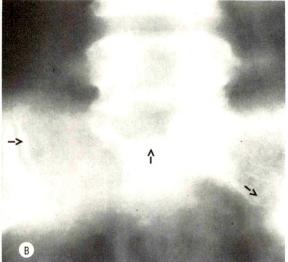


Fig. 20. Case VI. Admission roentgenogram of lumbosacral spine (A) revealed questionable changes of the right wing of the sacrum. Many overlying gas shadows are seen. Lateral and oblique roentgenograms were interpreted as negative. Polydirectional laminagrams (B and C) reveal almost complete lysis of the right wing of the sacrum, pathologic fracture of the centrum of the first sacral and a small lesion of the left wing of the sacrum. Oblique laminagram (C) confirms the fracture of the first sacral segment and shows two unsuspected areas of lysis of the fifth lumbar vertebra.

grams should be made. The patient was called from the operating room just prior to the administration of an anesthetic. Additional polydirectional laminagrams (Fig. 19C) in the lateral projection showed this to be a deciduous cyst arising from a tooth bud and projecting into the floor of the antrum. The patient was returned to the operating room where an operative procedure was performed by the Dental Service rather than the Ear, Nose and Throat Service.

Case vi. A 56 year old white woman was admitted to the Neurosurgical Service with a history of sciatic-type pain radiating to the right leg of 5 months' duration. The roentgenograms

taken on admission demonstrated equivocal osteolysis of the right wing of the sacrum (Fig. 20A). Laminagrams revealed almost complete lysis of the right wing of the sacrum, a pathologic compression fracture of the centrum of the body of the first sacral with dense areas of bone in this area suggesting sequestra (Fig. 20B). The oblique view (Fig. 20C) showed partial destruction of a lateral margin of the first sacral and there were two large lytic areas in the body of the fifth lumbar vertebra, which could not be seen on review of the plain roentgenograms. The changes noted on the laminagrams were suggestive of metastatic malignancy, and, upon seeing these skeletal changes, the Neurosurgical Service re-examined the patient's rectum and found a small carcinoma. The changes in the bone were thought to represent lymphatic extension from this primary neoplasm.

### SUMMARY

Multidirectional obscuring movements result in laminagrams of superior diagnostic quality, which surmount the geometric shortcomings of unidimensional blurring. The authors feel that this roentgenographic method permits more precise evaluation of spatial relationships, particularly in the skeletal system, and therefore, provides a significant diagnostic advantage not heretofore appreciated by American radiologists.

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The authors wish to recognize the technical skill of Miss Virginia Wilcox, R.T. Her ingenuity and generous devotion of time quickly gave us laminagrams of excellent technical quality, thus identifying the clinical value of this procedure. She has made a significant contribution to this diagnostic roentgen method.

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## SIMPLE ROENTGENOGRAPHIC DEMONSTRATION OF EUSTACHIAN TUBES AND ABNORMALITIES\*

By M. H. WITTENBORG, M.D., and E. B. D. NEUHAUSER, M.D. BOSTON, MASSACHUSETTS

WHAT is known about the normal and pathologic anatomy of the eustachian tube in humans is primarily derived from postmortem observations and a few intubation and pressure and dye flow studies. 1,3-7,9,10,12 Roentgenographic demonstrations have been few. Retrograde injections of opaque medium through the nasal orifice 1,3 and later through the ear drum 2 have not been widely accepted as clinical diagnostic techniques.

This is a presentation of a simple clinically applicable method for the roentgenographic visualization of the eustachian tubes without instrumentation or anesthesia successfully used for the past 3 years.

Approximately 75 examinations have been performed on infants, children and adults. Clinical studies applying this technique are currently in progress. Some preliminary observations are presented as pertinent to the application of the technique.

## TECHNIQUE

The patient is examined in the supine position under a roentgenographic image system-spot film device. The shoulders and trunk are elevated by mattress or similar device to permit enough posterior extension of the neck for a satisfactory submentovertical view of the base of the skull (Fig. 1). This position is necessary for pooling the radiopaque medium in the posterior nasal cavity opposite the eustachian tube orifices (Fig. 2, A and B). The submentovertical view is the optimum projection for the roentgenographic visualization of the eustachian tube.11 An aqueous medium or aqueous emulsion of an oily medium is used as it has desirable properties of surface

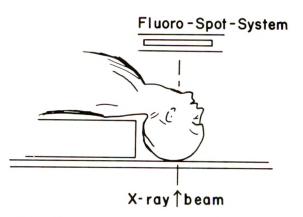


Fig. 1. Positioning of the patient for examination.

tension and viscosity. In addition, a watery medium has physical properties similar to nasal content or aspirated material and should behave in a comparable manner.\*

Ten to 20 cc. of the medium is injected via nasal catheter into the posterior nasal cavity under fluoroscopic or image system guidance. Roentgenograms may be made during the injection and it is our custom to make spot roentgenograms at rest, during swallowing, and during a Valsalva maneuver (Fig. 3, A–E).

Although single roentgenograms in the lateral view of the nasal pharynx have routinely been taken after roentgenograms in the submentovertical projection, they usually fail to show the eustachian tube as a result of the change in position and the rapid clearance of the opaque medium. They serve as a frame of reference<sup>11</sup> (Fig. 4), giving the topography of the nasal pharynx.

<sup>\*</sup> Undiluted commercially available aqueous bronchographic media (Dionosil and Hytrast) as well as oral aqueous emulsions (oral Ethiodol) have been used successfully.

<sup>\*</sup> From the Children's Hospital Medical Center and Harvard Medical School, Boston, Massachusetts. Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D. C., October 2–5, 1962.

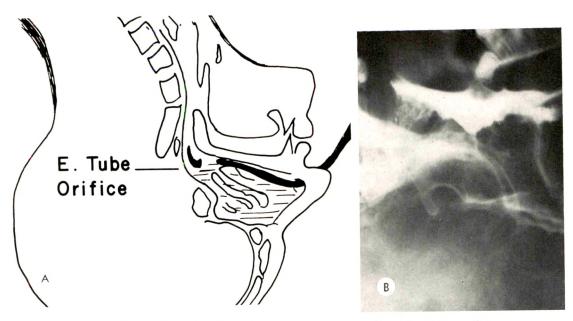


Fig. 2. (A and B) Sketch and roentgenogram showing pooling of opaque medium.

### ANATOMY

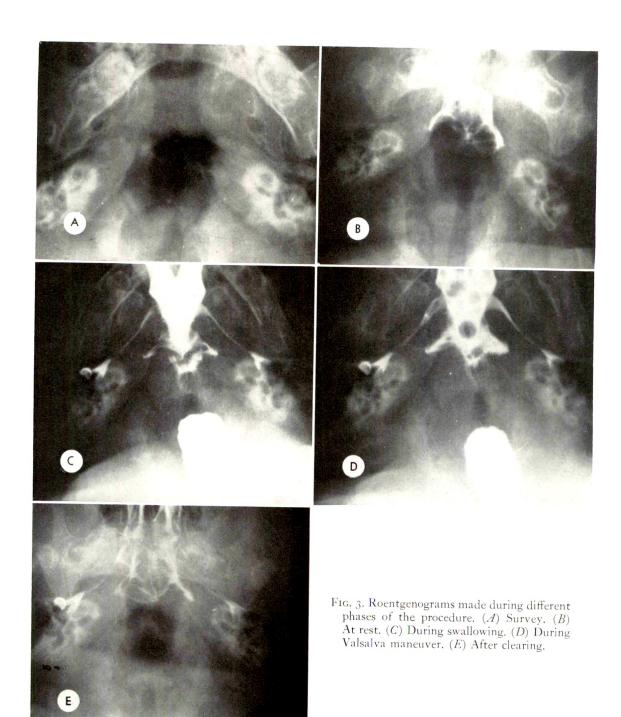
The eustachian tubes normally vary in length from 14 to 18 mm. in the newborn to 32 to 36 mm. in the adult. The course as described from postmortem studies from ear to pharynx is a diagonal 45° descent from the horizontal and 40–45° from the sagittal plane3 (Fig. 5, A-C). The lumen of the cartilaginous portion, constituting the anterior medial two-thirds, is normally closed but opens periodically during the act of swallowing, normally about once or twice a minute.3 The lumen of the osseous portion constituting the posterolateral one-third is normally open. The narrowest portion of the tube is at the junction of the osseous and cartilaginous portion known as the isthmus (Fig. 6, A and B).

The tube lining is ciliated columnar epithelium with seromucinous glands of mixed type being present with increasing frequency toward the pharyngeal end. There are no glands in the bony portion.

Submucosal well defined nodules of lymphoid tissue may be found in the postnasal cavity just behind the tubal orifice in the posterior pharyngeal recess (fossa of Rosenmüller). When grossly enlarged, these are often referred to as "tubal tonsils" or "lateral adenoid tabs." The presence of true lymphoid tissue along the course of the tubes has been commonly assumed, but apparently never positively confirmed.<sup>3,14</sup>

No regulatory reflex mechanism for opening the tube, either independently or by swallowing, has been demonstrated.9 The tensor palati muscle probably is the only one functionally involved in opening and closing the tube. Contraction of this muscle by virtue of its origin on the cartilage dilates the tube orifice and lumen by its tension and straightening effect on the inverted hook-shaped cartilage which makes up the medial and superior walls of the medial two-thirds of the tube. Closure of the tube is a passive phenomenon resulting from relaxation of the tensor palati muscle with a return of the tubal walls to the condition of approximation which they normally assume at rest.9

Fluid introduced into the middle ear normally appears at the pharyngeal orifice from 1 second to 10 minutes later and



clears from the normal middle ear in approximately 10 minutes.<sup>2,10</sup>

The familiar clinical landmark of the eustachian tube orifice, the torus tubarius, is the pharyngeal end of the cartilaginous hook-shaped medial and superior wall of the tube which enlarges in the submucosal area of the posterolateral nasal cavity forming the prominent landmark between the orifice and the posterior pharyngeal recess (fossa of Rosenmüller) (Fig. 6, A and B).

A "flutter valve" at the nasal orifice of the tube is postulated by many. It is made up of the collapsed soft tissue at the nasal end which closes when the salpingopharyngeal fold and the salpingopalatine fold collapse as a result of the respective underlying muscle fibers, the salpingopharyngeus and levator palati muscles.

### OBSERVATIONS

The eustachian tubes are normally functionally closed and open on tensing the soft palate as in swallowing (Fig. 3 C). If aided by gravity, postnasal content spurts jet-like into the cartilaginous portion of the eustachian tubes on opening. On closure, clearing is instantaneous. If aided by increased intranasal pressure as in the Valsalva maneuver, the tubes will not normally fill unless opened by swallowing or a similar maneuver. When opened simultaneously with increased intranasal pressure, their entire length is filled and sometimes the content spills into the middle ear (Fig. 3 D and 6 B). The cartilaginous portion clears promptly; the osseous portion retains the content for 10 or more minutes.

The eustachian tubes are more readily visualized in newborns and infants than in older children and adults (Fig. 7, A–C). Obstruction of the eustachian tubes by "tubal tonsils" may be demonstrated (Fig. 8, A and B). Patency of eustachian tubes, so essential for successful tympanoplasty, may be evaluated by this simple roentgenographic technique (Fig. 9, A and B).

## SUMMARY

A simple technique for the visualization

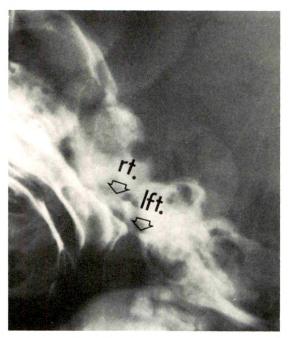


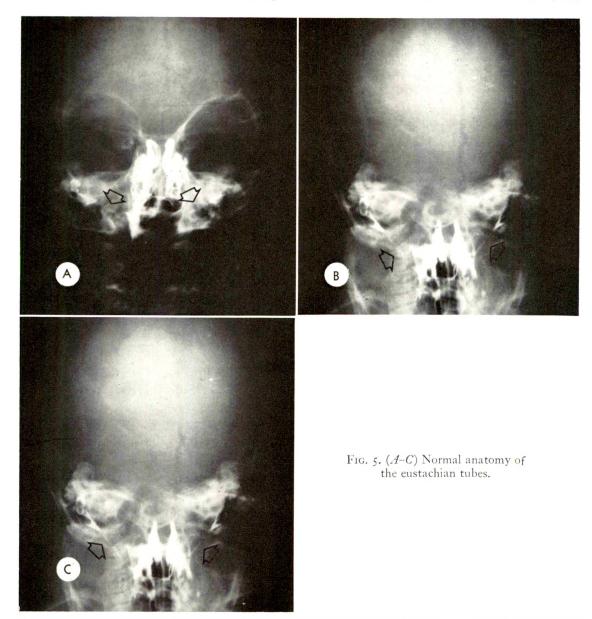
Fig. 4. Lateral roentgenogram shows the topography of the nasal pharynx.

of the eustachian tubes without instrumentation or anesthesia is described and preliminary observations are presented.

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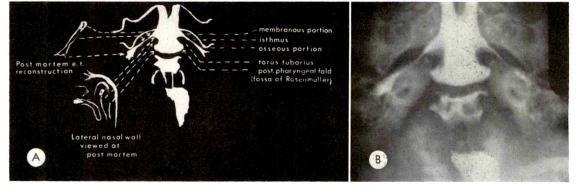
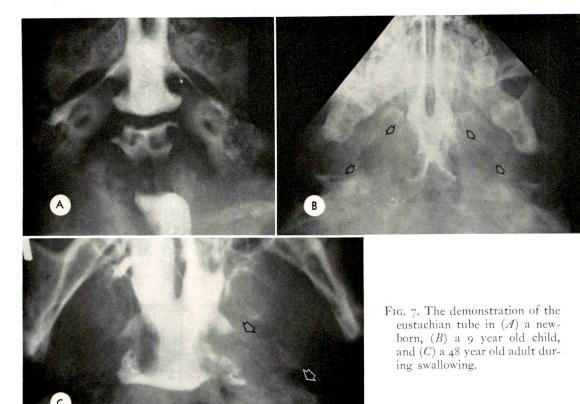


Fig. 6. Schematic presentation of anatomy (A) as visualized roentgenographically (B).



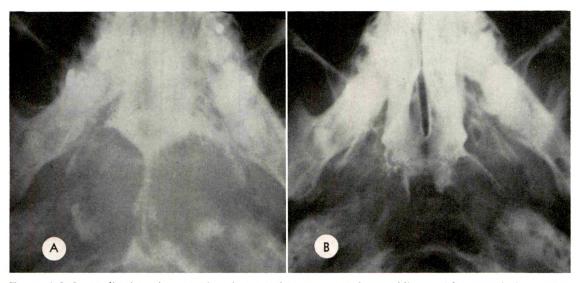


Fig. 8. (A) On swallowing, the posterior pharyngeal recesses are almost obliterated by posteriorly and laterally placed soft tissue masses (lateral adenoid "tabs"). The eustachian tube orifices are displaced anteriorly and there is nonfilling of the eustachian tubes. (B) Six weeks following operative removal of adenoid "tabs." The left eustachian tube fills well; the right is still not opacified. Clinically this 8 year old boy had severe bilateral conductive deafness despite two previous adenoidectomies elsewhere. Following removal of adenoid "tabs" demonstrated above, the hearing returned to normal in 6 weeks as proved by audiogram.

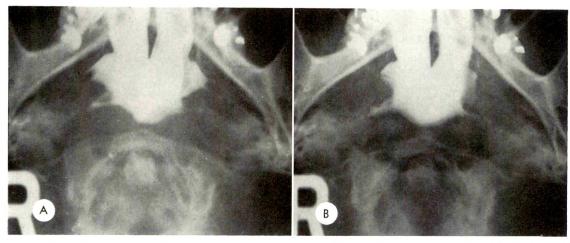


Fig. 9. Nasotubograms on a 36 year old female with impaired hearing bilaterally and a history of recurrent bilateral chronic suppurative otitis media since early childhood and gross perforations of both ear drums. The examination performed for evaluation prior to tympanoplasty shows normal posterior pharyngeal contour at rest (A) but failure of opacification of the eustachian tubes on Valsalva maneuver (B). Obstruction of the eustachian tubes was also suggested on politzerization studies.

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## ROENTGENOGRAPHIC MANIFESTATIONS OF TUMORS OF THE GLOMUS JUGULARE (CHEMODECTOMA)\*

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THE glomus jugulare is a relatively obscure body of chemoreceptive tissue located in the region of the jugular foramen. Although the glomus jugulare was recognized as an anatomic entity only two decades ago, the medical literature now contains approximately 200 reported cases of tumors arising in this structure. In this paper the results of our analysis of the roentgenographic features of 22 proved cases of glomus jugulare tumor are described.

### REVIEW OF THE LITERATURE

The first anatomic description of the golmus jugulare was published by Guild9 in 1941. In this and a subsequent article, Guild reported finding these small bodies in the immediate vicinity of the jugular bulb, just beneath the petrous portion of the temporal bone. 10 In 1945, Rosenwasser 19 reported the first case of a tumor arising in the glomus jugulare. More recently, in several excellent articles the literature on this subject has been reviewed and a rather characteristic syndrome associated with this tumor has been defined. 1-4,8,20,23 Typically, the patient is middle-aged and relates a history of polyps or infections of the ear of long standing. Tinnitus is frequently the presenting complaint. Almost invariably there is some loss of hearing in the involved ear, and not uncommonly there are symptoms referable to involvement of cranial nerves other than the eighth nerve. The tumor occurs more commonly in women than men in a ratio of 4 or 5 to 1. In many cases, the tumor itself is seen as a dark-red or blue mass behind the tympanic membrane or extending into the external auditory canal.

Glomus jugulare tumors are definitely locally invasive and the possibility of intra-

Table I

AGE, SEX AND DURATION OF SYMPTOMS BY
ROENTGENOGRAPHIC GROUP

Group	Case	Age	Sex	Duration of Symptoms (yr.)
I	I	62	F	4
	2	4 I	F	1.5
	3	43	$\mathbf{F}$	7
	4	55	F	10
	Ave.	50		5.6
2	5	46	F	8
	5 6	56	F	II
		52	$\mathbf{M}$	15
	7 8	35	F	2
	9	42	F	15
	10	51	F	I.5
	ΙΙ	47	$\mathbf{M}$	3
	12	65	F	3
	13	49	F	3 2
	14	36	F	2
	15	66	F	1.3
	Ave.	49.5		5.8
3	16	56	F	6
	17	33	F	2.5
	18	45	F	12
	19	45 60	$\mathbf{M}$	5
	20	37	F	3
	21	36	F	3 7
	22	53	F	10
	Ave.	45.7		6.5

<sup>\*</sup> Presented at the Sixty-third Annual Meeting of the American Roentgen Ray Society, Washington, D.C., October 2-5, 1962.

Abridgment of thesis submitted by Dr. Rice to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Radiology.

Table II						
FREQUENCY OF CLINICAL FINDINGS I	BY ROENTGENOGRAPHIC GROUP					

Group	Total Cases	Abnormal Tympanic Membrane or Mass in Ear	Hearing Loss	Tinnitus	Aural Discharge	Cranial Nerve Involvement (other than eighth)
I	4	3	3	3	I	I
2	ΙΙ	II	11	6	4	5
3	7	6	7	4	I	6
Total	22	20	21	13	6	12

cranial extension represents a real threat to life, but actual metastasis has been well documented in only a few cases. <sup>18,21</sup> There also have been a number of deaths associated with uncontrollable hemorrhage following even minor surgical procedures in the diagnosis and treatment of glomus jugulare tumors. In a compilation, by Bickerstaff and Howell, <sup>1</sup> of 87 cases there were 20 deaths attributed to this tumor.

Many of the papers on the subject of glomus jugulare tumors have included the roentgenographic findings in the case reports, and a few have dealt specifically with the roentgenographic aspects of this tumor.<sup>7,11–15,17</sup>

Probably the most common roentgenographic finding which has been reported is sclerosis and clouding of the mastoid on the ipsilateral side. There also have been a large number of cases in which destruction or erosion of a portion of the petrous pyramid has occurred. Several authors have called attention to the fact that this erosion seemed to begin on the inferior surface of the petrosa and spared the superior surface until late in the course of the disease. 5,11,13,14 Enlargement of the jugular foramen has been reported in a number of cases, and a few authors have mentioned increased vascularity in the region of the tumor which was delineated by carotid angiography. 11,13,14,17 In several cases, the roentgenograms showed a soft-tissue mass extending into the nasopharynx.<sup>17</sup>

#### RESULTS

Selection of Patients. This series of 22 cases of glomus jugulare tumor taken from the records at the Mayo Clinic corresponds, in general, to other published series. The pertinent clinical findings are shown in Tables I and II, where they are correlated with the roentgenographic findings. Nine-

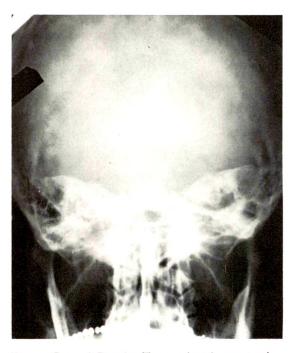


Fig. 1. Case 16. Routine Towne view demonstrating area of destruction on the inferior surface of the left petrous pyramid. Stenvers' views and stereoscopic views of the base of the skull did not reveal the lesion.

teen of the patients were females, and the average age was 48 years. Symptoms had been present for an average of 6 years before the correct diagnosis was established. Loss of hearing, tinnitus, and aural discharge were the most common symptoms. Twelve patients had signs or symptoms of involvement of cranial nerves other than the eighth. A mass, either within the external auditory canal or behind the tympanic membrane, was seen in about half of the patients. None of the patients had evidence of metastatic spread of the chemodectoma, although one patient subsequently was found to have a carotid body tumor of the contralateral side of the neck. The coexistence of multiple tumors of the chemoreceptive system has been reported by others.1,8

Roentgenographic Features. Roentgenographically, the 22 cases in our series fall



FIG. 2. Case 17. Routine Towne view demonstrating a somewhat larger lesion of the inferior surface of the left petrous pyramid. Roentgenograms taken 6 years later revealed more extensive destruction with involvement of the superior surface of the petrous ridge as well.



Fig. 3. Case 20. Another Towne view showing obvious destruction of the inferior surface of the left petrous tip. Note the similarity between the localized destruction in this case and in Figures 1 and 2. A total of 6 patients in our series had similar findings.

conveniently into three groups. Group I includes those cases in which the roentgenograms were completely noncontributory to the diagnosis of chemodectoma. There were 4 cases in this group. Group 2, the largest group, is made up of those cases in which the roentgenographic findings were apparently related to the glomus jugulare tumor but were nonspecific. In all II patients of this group, there were changes suggestive of chronic mastoiditis, which were either limited to or most marked on the side bearing the tumor. There was sclerosis, or destruction of mastoid air cells, or both, in varying degrees.

In each of the remaining 7 cases, which make up Group 3, there was a roentgenographically demonstrable area of destruction in the petrous pyramid. In 6 of these, the roentgenographic changes were quite similar, being characterized by an area of destruction 2 to 4 cm. in diameter on the inferior surface of the petrous pyramid. This

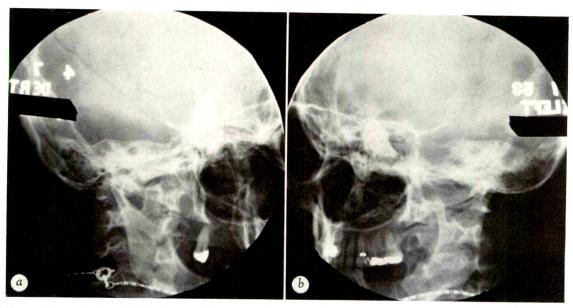


Fig. 4. Case 18. (a and b) Left and right Stenvers' views showing destruction of the inferior surface of the left petrous tip with sparing of the superior surface of the petrous pyramid. The normal right petrosa is shown for comparison.

typical area of destruction was always in the medial half of the petrous pyramid and had irregular margins indicative of bone destruction rather than pressure erosion (Fig. 1 through 5). The seventh patient in this group had such extensive destruction of the bones of the middle cranial fossa and sphenoid sinus that it was possible to say only that there was some invasive tumor in this area (Fig. 6, a and b). Five patients in this group had roentgenographic evidence of chronic mastoiditis in addition to the lesion in the petrous pyramid.

From our findings it seems that there are two different types of roentgenographic abnormality associated with glomus jugulare tumors. Sixteen of 22 patients had a typical roentgenographic appearance of mastoiditis. This was obviously nonspecific for chemodectoma. Pathologically, the opacification or sclerosis of the mastoid cells is infrequently a manifestation of invasion by the tumor. It seems likely that the chronic mastoiditis was a result of secondary infection associated with damage to the middle ear and tympanic membrane, which so frequently occurs.

The second and more important roentgenographic manifestation of this tumor was a demonstrable area of destruction in the petrous portion of the temporal bone. This was present in 7 patients, and in 6 of these, the changes were stereotyped. Typically, there was an area of destruction involving the inferior surface of the petrous pyramid. We believe that this picture is characteristic of an advanced chemodectoma. In the very late stages of the disease, there may be extensive destruction of the petrous pyramid and other bones of the middle cranial fossa (Fig. 7).6

In general, there was very little correlation between duration or severity of symptoms and degree of roentgenographic involvement. We did find, however, that the incidence of involvement of the cranial nerves was highest among those patients with destruction of bone. Siekert<sup>22</sup> has previously reported this observation, and his work was based on a neurologic analysis of many of the same patients used in our series. Since both phenomena are manifestations of the local extension of the tumor, this coincidence is reasonable.

The bone destruction which we have described was apparent in the Towne view in every case, although there was one patient in whom the lesion was seen to greater ad-

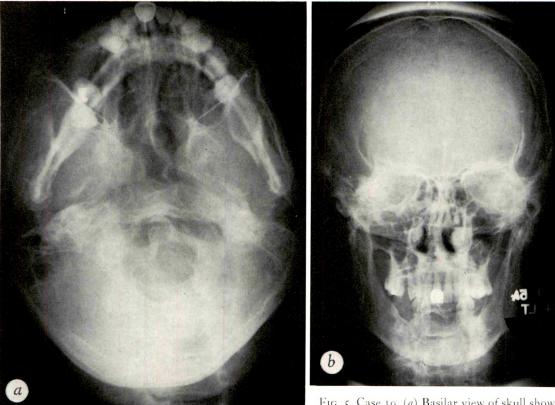


Fig. 5. Case 19. (a) Basilar view of skull showing destruction of the petrous tip on the left.

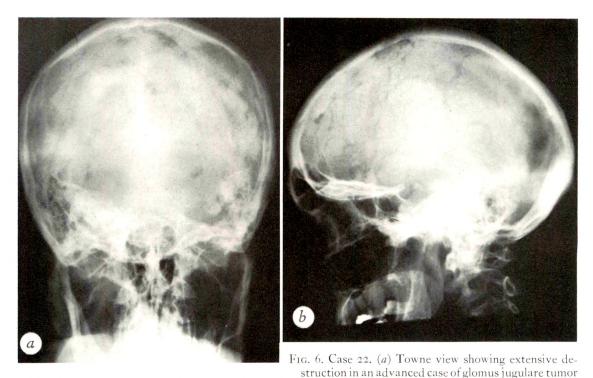
The defect was more apparent on the original stereoscopic roentgenograms. (b) Routine posteroanterior projection of the skull demonstrating that the area of destruction seen in a is localized to the inferior surfaces of the left petrous tip. In this case, the lesion was seen better in the posteroanterior projection than on the Towne view.

vantage in the routine posteroanterior view of the skull (Fig. 5b). Stenvers' view was almost as reliable as the Towne view in the demonstration of the osseous defect, and was available in 6 of the patients in Group 3. In 5 of these, the Stenvers' view did reveal the bone destruction, although in most cases the abnormality was best shown in the Towne view. One Stenvers' view was interpreted as normal in spite of a demonstrable defect on the Towne view taken as part of the same examination. Stereoscopic basilar views of the skull were available in 3 patients in Group 3, and the destruction was apparent in only 1 (Fig. 5, a and b). Eraso<sup>7</sup> has described a special technique for demonstration of the jugular foramen which should be of value when glomus jugulare tumors are suspected.

Laminagraphic examination of the pet-

rous ridge was performed in Case 20 in order to evaluate the area of bone destruction seen on the routine Towne view. Holesh<sup>13</sup> has pointed out the value of laminagrams for defining areas of bone destruction associated with chemodectomas, and we agree that this is a worthwhile procedure in a patient with a suspected osseous defect. It may be that, by means of laminagraphy, it would have been possible to demonstrate destruction of bone in a few cases in which the petrous pyramid appeared normal in the routine projections. Carotid arteriograms were available in I case and were normal. The experience of others, however, clearly shows that arteriography does have a place in the diagnosis and evaluation of glomus jugulare tumors.

In general, we must conclude from our study that the standard Towne and Sten-



with intracranial extension. (b) Lateral view in the same case. The mass can be seen to be encroaching on the posterior part of the sphenoid sinus and has destroyed the clivus, the posterior portion of the sella turcica, and the lower half of the dorsum sellae. This was the most extensive involvement of any case in our series.

vers projections are the most reliable views in the routine roentgenographic evaluation of patients with proved or suspected glomus jugulare tumors. As a Towne view is generally included in a routine skull examination, and the Stenvers view is part of most roentgenographic investigations of the mastoid or middle ear, the demonstration of the typical lesion which we have described does not require any special procedures in the majority of cases.

# ROENTGENOGRAPHIC DIFFERENTIAL DIAGNOSIS

Although the roentgenographic findings in 6 cases in our series can be regarded as characteristic of advanced glomus jugulare tumors, various other conditions must be included in the roentgenographic differential diagnosis.

Acoustic Neuroma. The most common roentgenographic finding associated with neurofibromas of the eighth cranial nerve is

pressure erosion in the region of the internal auditory meatus. In our series of chemodectomas there was only I patient with enlargement of the internal auditory canal. The lesion associated with chemodectoma is usually on the inferior surface of the petrous pyramid rather than along the course of the eighth nerve. A final point of differential value is the moth-eaten, irregular appearance of the osseous defect associated with chemodectomas, which is in contrast to the smooth, sharply demarcated margin of the usual defect associated with eighth nerve neurofibroma.

Meningioma of the Petrous Ridge. Meningiomas that cause hyperostosis of the underlying bone, in this case the petrous ridge, should not be difficult to differentiate from glomus jugulare tumors. Both meningiomas and glomus jugulare tumors may destroy the petrous tip, but the latter type of tumor often spares the superior surface. A few meningiomas contain calcium, which



Fig. 7. Section of specimen in Case 17 demonstrating the actual invasion and destruction of bone by a chemodectoma (hematoxylin and eosin; ×110).

has not been reported in glomus jugulare tumors. It is apparent, however, that a roentgenologic differentiation between these two tumors will not always be possible.

Chronic Mastoiditis. A high percentage of patients with glomus jugulare tumors have the roentgenographic changes associated with chronic mastoiditis. However, if there is also destruction of the petrous tip, an uncomplicated mastoid infection can be excluded. Cholesteatoma formation secondary to chronic infection of the middle ear typically occurs in the region of the mastoid antrum and is usually demarcated by a margin of sclerosis which is not seen with chemodectomas.

Chordoma. The notochordal remnant from which cranial chordomas arise is a midline structure in the region of the clivus. It rarely, if ever, causes unilateral destructive changes such as are typical of chemodectomas of the glomus jugulare.

Primary and Metastatic Malignancy. A malignant tumor arising in the region of the middle ear, or even in the sphenoid sinus or nasopharynx, may be roentgenologically indistinguishable from an advanced glomus jugulare tumor. Similarly, a

metastatic lesion from a primary source anywhere in the body may cause destruction of the petrous tip identical to the findings which we have described. It is possible that angiography may be of value in some of these cases, but the ultimate diagnosis will depend upon the histologic examination of tissue.<sup>17</sup>

## SUMMARY AND CONCLUSIONS

In a review of the roentgenographic features of 22 proved cases of glomus jugulare tumor, we found 7 cases in which there were definite areas of destruction in the petrous pyramid. The lesions in 6 of these 7 cases were quite similar in appearance, and were characterized by an area of bone destruction 2 to 4 cm. in diameter on the inferior surface of the petrous tip. In 16 cases there was evidence of chronic mastoiditis on the ipsilateral side. This latter finding is obviously quite nonspecific unless associated with the area of destruction in the petrous pyramid.

A brief discussion of the roentgenographic differential diagnosis is included. In view of the frequent complications of the surgical management of these tumors, we believe that accurate preoperative diagnosis is of more than academic interest. An increased awareness of glomus jugulare tumors and their potential roentgenographic manifestations will enable the radiologist to be of greater assistance in the diagnosis of this tumor.

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## THE PINEAL TOMOGRAM\*

## VISUALIZATION OF THE FAINTLY CALCIFIED PINEAL GLAND

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ACCURATE localization of the calcified pineal gland remains the single most significant observation to be made on skull roentgenograms of the majority of adult patients with the clinical suspicion of an expanding intracranial lesion. This calcification is often sufficient to be clearly seen on a routine lateral roentgenogram of the skull but may not be visible on all posteroanterior and anteroposterior roentgenograms, including adequate stereoscopic films. The faint calcium fleck may be obscured by a

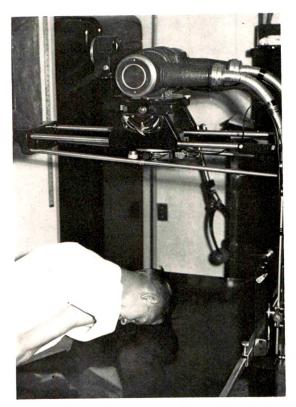


Fig. 1. Patient correctly positioned for pineal tomography.



Fig. 2. Vertical tomogram. The pineal gland is obscured. There is streaking of midline structures.

thick midline occiput in the Towne or semi-Towne projection or by the frontal sinuses in the direct anteroposterior or posteroanterior roentgenogram.

The purpose of this paper is to present a simple method of demonstrating pineal calcification that is otherwise obscured.

## TECHNIQUE

The patient is placed in the prone position on a stretcher angled 45 degrees to the table (Fig. 1). Angulation of the patient is used as in sternal tomography, to prevent vertical streaking by midline structures such as the nasal septum, occipital protuberance and calcified falx cerebri (Fig. 2). A more elaborate tomographic apparatus than the attachment used here might well obviate the necessity for angulation of the

<sup>\*</sup> From the Department of Radiology, Duke University Medical Center, Durham, North Carolina. Presented as a scientific exhibit at the Sixty-second Annual Meeting of the American Roentgen Ray Society, Miami Beach, Florida, Sept. 26-29, 1961.

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<sup>‡</sup> Fellow, American Cancer Society.

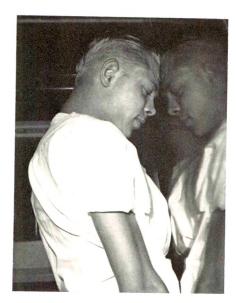


Fig. 3. The canthomeatal line is directed 25 degrees toward the feet.

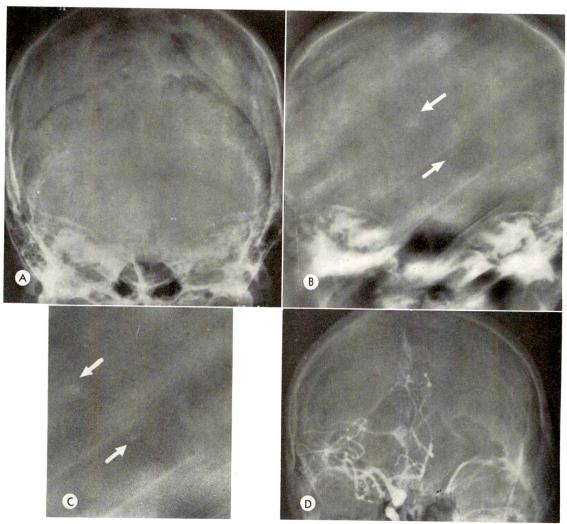


Fig. 4. (A) The pineal gland is not visible on the anteroposterior roentgenogram. (B) A tomogram shows the pineal gland displaced to the left (lower arrow). The right choroid glomus is displaced medially (upper arrow). (C) Magnified view showing the shifted pineal gland and choroid glomus. (D) Right carotid arteriogram showing a temporal lobe mass.

patient. The canthomeatal line is directed 25 degrees toward the feet to prevent the area of the pineal gland from being obscured by the facial structures (Fig. 3). A similar caudad tilt of the head in the anteroposterior (semi-Towne) position under the zero point of the tube sweep is not recommended since this would require elevation of the head from the table, producing considerable film distortion. Lower kilovoltage than that employed in routine skull roentgenography is used. The usual factors are: 70 kv. peak, 36 inch target-film distance, 100 ma. and 3 seconds. The tube arc is 45 degrees with a 19.5 inch shift.

Several tomographic sections are taken in the region of the pineal gland. This point can be easily determined from measurement of the lateral roentgenogram.

Figure 4A shows that the pineal gland is not visible on the conventional anteroposterior roentgenogram. A tomographic section made at the level of the pineal gland demonstrates this structure (Fig. 4, B and C). The right choroid glomus, also not visible on the routine roentgenogram, is displaced upward and toward the midline. A subsequent right carotid arteriogram confirmed the shift of the midline structures and demonstrated the vascular shift of a temporal lobe mass (Fig. 4D).

In every instance where this technique has been used, the calcified pineal gland has been accurately demonstrated.

## DISCUSSION

In a review of the literature, we were unable to find reference to the utilization of cranial tomography for pineal localization. To determine how often this procedure might be applied, the routine stereoscopic skull roentgenograms of 200 adult patients were reviewed. One hundred and twenty-four cases demonstrated visible pineal calcification on the lateral roentgenograms. In 49 of these cases no pineal shadow was seen in the anteroposterior projections.

This simple procedure can be easily performed in any radiology department with tomographic equipment available.

### SUMMARY

A simple tomographic technique is described for demonstrating pineal calcification when it is obscured on conventional anteroposterior and posteroanterior roent-genograms.

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## ROUTINE SKULL ROENTGENOGRAPHY OF PSYCHIATRIC HOSPITAL ADMISSIONS\*

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**D**ATIENTS referred to psychiatric hospitals are routinely checked from a neuropsychiatric standpoint; rarely are their skulls examined roentgenologically for possible brain lesions. Such examinations, however, are advisable because unsuspected cerebral neoplasms are occasionally detected in deceased psychotics.5

While the incidence of brain tumors in the general population is estimated as I per cent, in large mental institutions it has been reported as 3.5 per cent6 and even as high as 5 per cent<sup>3</sup> according to autopsy findings. Therefore, an organic brain lesion, either superimposed upon a psychosis or simulating psychotic behavior, must always be kept in mind. McIntyre and McIntyre9 state that a cerebral neoplasm can masquerade as Alzheimer's disease, cerebral arteriosclerotic dementia, Parkinson's disease, alcoholism, encephalitis, Fröhlich's syndrome with mental deficiency, general paresis, schizophrenia and anxiety neurosis.

The search for an organic lesion in the mentally ill is important, since 25 per cent of the brain tumors are meningiomas. Many of these are operable, and their prognosis for survival and relief of symptoms is good.5 In view of these observations, skull screening in mental institutions appears logical. A long search of the literature, however, fails to reveal any previously conducted survey.

Such lack is not surprising since conventional skull roentgenograms do not disclose abnormalities in 50 per cent of patients with brain tumors.9 Therefore, only routine neurologic testing of psychotics is empha-

sized by Tissenbaum et al.,14 Simon,12 and Martin,8 but simple skull screening is not stressed in ruling out an organic lesion. On the other hand Moersch et al.10 find that roentgen signs of increased intracranial pressure can be detected in 30 per cent of patients prior to clinical manifestations. In our experience this is especially true with tumors in and around the sella turcica.

The only known skull survey of patients in a psychiatric hospital was recently presented by Traub<sup>15</sup> as a preliminary report. The author was stimulated by the discovery of an unsuspected meningioma in a "psychotic" who had received electroshock treatments for 9 months. His tabulation of 1,505 cases revealed "significant" findings in 5 per cent (84 cases).

## SKULL PROJECT

In 1958, at the Northport Veterans Administration Hospital, we decided to embark upon a skull screening program after we had encountered the following unsuspected roentgen findings in 8 psychotic patients during the preceding year: abnormal calcifications in brain and calvarium, 3 patients; hemangioma, 2 patients; sclerotic changes in the middle fossa, I patient; pituitary adenoma, I patient; and osteolytic skull defect, I patient.

We limited our study to new psychiatric hospital admissions, instead of doing a survey of hospitalized patients as reported by Traub.15 Patients already under long-term hospital care and re-admissions were excluded. All patients were men ranging in age from 19 to 65 years.

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Fig. 1. Asymptomatic pituitary adenoma.

Roentgen signs of significance were ballooning and erosion of the sella turcica, suprasellar calcifications in craniopharyngioma, increased vascular markings in meningioma, calcific deposits in tumors, pineal shift and pressure defects of the petrous ridges. Incidental calcifications of the dura, the falx and the cranial tables were not tabulated. Calcifications in hypoparathyroidism, tuberculoma, tuberous sclerosis, toxoplasmosis and other infectious processes were not encountered in our series.

Over a period of 3 years, the findings in 1,000 consecutive new admissions, consisting of 501 direct admissions and 499 admissions by transfer from other institutions, were tabulated and the following unsuspected conditions were detected in 17 patients (1.7 per cent): pituitary adenoma with acromegaly, 7 patients; pituitary adenoma, 4 patients; Paget's disease with basilar impression, 3 patients; tumor calcifications, 2 patients; and petrous ridge tumor, 1 patient.

Of these 17 patients, 12 belonged to the group which had been transferred from other institutions and only 5 to the equally large group of direct admissions. Thus, the transfer group of patients yielded more than twice as many abnormal findings as the direct admissions. These results illusstrate the importance of skull screening, even though a thorough neuropsychiatric evaluation had been done prior to admission. A pituitary adenoma and a tumor cal-

cification of the series are shown in Figures 1 and 2, respectively.

## ENDOCRINE FEATURES

While searching primarily for intracranial neoplasms, we soon recognized a possible hormonal significance of the skull findings. Therefore, we added roentgenograms of the hands and obtained data regarding height, weight and appearance of the patients to corroborate certain endocrine features.

The most frequent roentgen change of endocrine significance was the hyperpituitary skull which we consider an early stage of acromegaly. This type is characterized by large paranasal sinuses, especially the frontals and sphenoids, hyperpneumatization of the mastoids, overgrowth of the mandible, and thickening of the cranial tables. The pituitary fossa usually is smaller than average size due to hyperpneumatization of the sphenoid sinuses. Thus, the hyperactive pituitary gland is apparently enlarged in width rather than in depth, as recently emphasized by Di Chiro and Nelson. An example of the hyperpituitary type skull is shown in Figure 3. Roentgenograms of the hands reveal large and long phalanges and metacarpal bones.

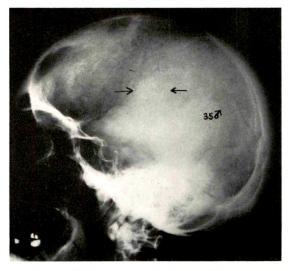


Fig. 2. Faint tumor calcification (between arrows) in parietal lobe, unsuspected.

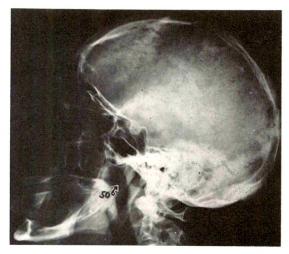


Fig. 3. Hyperpituitary-type skull. Hyperpneumatization of sinuses and mastoids, thickened tables, prognathism.

When the thickened tables are sclerotic and the bulging frontal sinuses have a flattened or concave outer contour, usually in patients over 50 years of age, it is presumed that transition from a hyperpituitary to a hypopituitary type has occurred. This can be interpreted as a burned-out hyperpituitary appearance as seen in Figure 4.

The roentgenologic evaluation of hyperpituitary types requires special care as one has to rule out simulating conditions such as fibrous dysplasia, Paget's disease, osteoporosis circumscripta, healed rickets, craniosynostosis, blood dyscrasias, gigantism, racial variations and others.

#### RESULTS

1. Total Admissions. The hyperpituitary type was encountered in 36 per cent of all patients, but it was more prevalent in the

Table I

FREQUENCY OF HYPERPITUITARY TYPE
IN TOTAL ADMISSIONS

	Total	Hyperpituitary Type			
Psychotics	680	42% (287)			
Nonpsychotics	320	23% (74)			
Total	I,000	36% (361)			

psychotics (42 per cent) than in the non-psychotics (23 per cent) (Table 1).

The incidence of the hyperpituitary type in the psychotics was almost twice as high as in the nonpsychotics. Further clarification, however, was advisable since all degrees of emotional disturbances were included. Fortunately, the severe degrees could be grouped separately, while the patients with mild and transient upsets served as controls. Such a comparison was possible because the patients admitted by transfer suffered from a predominantly serious illness, whereas those who applied directly for admission were evenly divided between mild and serious types.

Among the 499 transfer patients, 87 per cent were psychotics and only 13 per cent nonpsychotics, while the 501 direct admission patients consisted of 49 per cent psychotics and 51 per cent nonpsychotics (Table II).

2. Admissions by Transfer. This group of 499 patients admitted by transfer from other hospitals and clinics presented mostly a serious disturbance which required long periods of hospitalization. The frequency of the hyperpituitary type in the 65 non-psychotics of this group was only moderately less than in the counterpart of 434

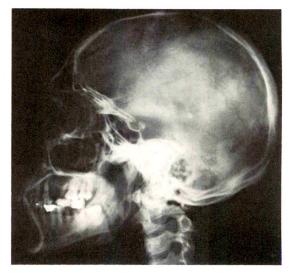


Fig. 4. "Burned-out" hyperpituitary-type skull. Findings similar to those in Figure 3, but tables are sclerotic and frontal sinus bulge is flattened.

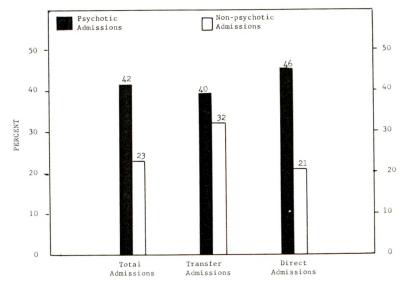


Fig. 5. Percentage of hyperpituitary-type skull changes.

psychotics (32 per cent against 40 per cent).

3. Direct Admissions. This group of 501 patients was admitted directly without preliminary screening by other hospitals or clinics. The large number of nonpsychotics (51 per cent), predominantly psychoneu-

TABLE II
FREQUENCY OF PSYCHOTICS IN TRANSFER
OR DIRECT ADMISSIONS

	Psy- chotics	Non- psychotics	Total
A. Admissions by Transfer	87% (434)	13% (65)	499
B. Direct Admissions	49% (246)	51% (255)	501

rotics with a history of alcoholism, required only a short hospitalization, and therefore could be utilized as controls. Interestingly enough, the incidence of hyperpituitary type skull findings in these 255 nonpsychotics was only 21 per cent against 46 per cent in the counterpart of 246 psychotics (Table III).

In this evaluation, the direct admissions are of special interest, as the hyperpituitary-type skull findings are present in almost one-half (46 per cent) of the psychotics but only in one-fifth (21 per cent) of the

nonpsychotics (controls). Comparative percentages of the hyperpituitary type in total admissions and the two separate groups are illustrated in Figure 5.

Much less frequent was the hypopituitary type with roentgen findings of sclerotic tables, hypopneumatized sinuses and a small mandible. It was encountered in 5 per cent, with 3.8 per cent in psychotics and 1.2 per cent in nonpsychotics. This type was frequently associated with hypothyroidism, while the hyperpituitary type was more often linked with hypogonadism. Metacarpals and phalanges of the hands were short and slender, as seen in Figure 8.4. An example of the hypopituitary-type skull is shown in Figure 6.

Shortening of the fourth and the fifth

Table III

FREQUENCY OF HYPERPITUITARY TYPE IN
TRANSFER OR DIRECT ADMISSIONS

	Total	Hyperpitui- tary Type
A. Admission by Transfer		
Psychotics	434	40% (175)
Nonpsychotics	65	32% (21)
B. Direct Admissions		
Psychotics	246	46% (112)
Nonpsychotics	255	21% (53)



Fig. 6. Hypopituitary-type skull. Hypopneumatization of sinuses and mastoids. Tables sclerotic, mandible small.

metacarpal bones was also noted during the study of the hand roentgenograms. This was measured by the use of the metacarpal sign of Archibald, Finby and De Vito. A positive sign was encountered in 97 patients (Fig. 8A), which is twice as high as in the general population (5 per cent). This observation is of interest because of a possible relation to endocrine abnormality.

# ILLUSTRATIVE CASE REPORT

A combination of pluriglandular dysfunction and a neoplasm was detected in the following case.

Fröhlich's Adiposogenital Dystrophy with Mental Deficiency and Suprasellar Tumor (Fig. 7, 8B, and 9). A 43 year old patient was transferred from another hospital where he had been treated for schizophrenic reaction, hebephrenic type, for 10 years. Routine skull roentgenograms on admission revealed a large suprasellar tumor covered by a curvilinear calcium shell, ballooning of the sella turcica with depression of its floor, thickening of cranial tables, also hyperpneumatization of sinuses and mastoids (Fig. 7). Roentgenograms of the hands disclosed brachydactylia with short, but broad tubular bones, denoting a hypothyroid type (Fig. 8B). These changes differed from the short, but slender tubular bones seen in hypopituitarism (Fig. 8A).

Subsequent inspection revealed Fröhlich's type adiposogenital dystrophy characterized by hypogonadism, gynecomastia, female distribution of fat, absence of pubic hair and a large trunk with proportionally short extremities (Fig. 9). The suprasellar tumor, like the pituitary adenomas in our series, was asymptomatic and therefore required no radical therapeutic measures. For the past 3 years the patient has been under medical care with endocrine management and has no longer exhibited psychotic behavior.

#### DISCUSSION

Routine skull surveys in psychiatric hospitals serve a double purpose: the detection of (1) brain tumors and (2) specific endocrine features.

1. Brain tumors are known to develop more frequently in the psychotics than in the general population. When the tumor is superimposed upon a psychosis of long standing, improvement of secondary personality changes but not of the psychosis can be expected following removal of the



Fig. 7. Routine admission skull roentgenogram. Suprasellar tumor covered by calcium shell. Ballooning of sella turcica. Hyperpneumatization of sinuses and mastoids.

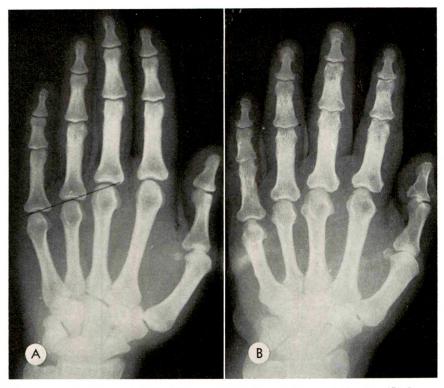


Fig. 8. (A) Same case as in Figure 6. Hypopituitary hand. Bones short and slender. (B) Same patient as in Figure 7. Hypothyroid hand. Bones also short but broad. Short fourth and fifth metacarpals.

growth. On the other hand, when psychotic symptoms are due to the tumor, a successful operation can result in complete rehabilitation.

A skull survey has so far only been reported by Traub<sup>15</sup> with "significant" findings in 5 per cent of the patients. Our survey reveals important findings in 1.7 per cent. Thus the yield is higher than in routine chest surveys for the detection of tuberculosis, which justifies continuation of the procedure.

2. In regard to specific endocrine features the hyperpituitary type was encountered most frequently (36 per cent). Among the direct-admission patients, it occurred in 46 per cent psychotics and in only 21 per cent nonpsychotics. Similar observations have also been reported by others.

Hoskins<sup>7</sup> stated in 1946: "In our own 1930 series of 130 cases pituitary dysfunction was diagnosed in 13, but the diagnostic criteria that were employed we now regard

as inadequate. In an occasional instance over the years we have detected in the X-ray plates of the skulls of schizophrenics evidences of hyperpneumatization and sclerosis of the cranial tables that indicate rather definitely the existence of early and prolonged pituitary dysfunction. But these have not occurred with sufficient regularity to justify the assumption that the hypophysis is selectively involved in the psychosis."

Traub<sup>15</sup> also noted many skull roentgenograms with thickened tables and hyperpneumatization of sinuses and mastoids. Caughey<sup>2</sup> found hyperpituitary-type skull changes associated with dystrophia myotonica. He stated that "gonadal atrophy is a common feature and endocrine study suggests that the endocrine defect is primarily a failure of the androgenic function of the adrenals and the testes."

Stewart<sup>13</sup> in 1928 reported localized cranial hyperostosis in the "insane." His patients were females with autopsy findings

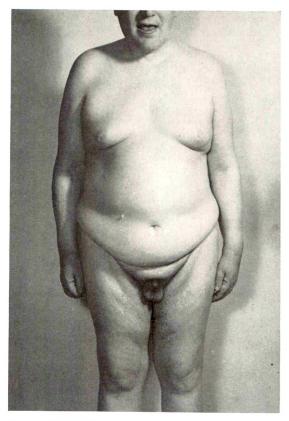


Fig. 9. Fröhlich's syndrome (adiposogenital dystrophy). Same case as in Figures 7 and 8B. Hypogonadism, gynecomastia, female distribution of fat, absence of pubic hair, large trunk with proportionally short extremities.

of internal frontal hyperostosis. He also cited similar observations dating back to the last century. Our series cannot be adequately compared as it consists entirely of male patients. A close relationship of endocrine and psychotic patterns is emphasized by Reiss<sup>11</sup> in his monograph on "Psychoendocrinology."

# THERAPEUTIC CONSIDERATIONS

In hypothyroids Hoskins<sup>7</sup> observed improvement of the mental condition following specific organic therapy. In pituitary dysfunction, however, he was "not aware of any convincing therapeutic studies in the literature." Therapeutic tests such as in our patient with Fröhlich's syndrome may in the future allow conclusions as to the relation of specific endocrine features and a coexisting psychosis.

A follow-up study of our first 500 patients revealed that an equal number with normal skulls and the hyperpituitary-type had required continued hospital care for 2 years and longer. Thus, the severity of the psychosis cannot be predicted from the skull findings. We believe, however, that re-evaluation of specific therapeutic approaches is advisable for the psychotic patient who exhibits any kind of endocrine dysfunction.

### SUMMARY

- 1. A routine skull survey of new psychiatric hospital admissions was started in 1958 for the detection of organic brain lesions. Roentgenograms of the hands were added to corroborate specific endocrine patterns.
- 2. In 1,000 patients the incidence of unsuspected important findings was 1.7 per cent, comprising 3 brain tumors, 4 pituitary adenomas, 7 acromegalics and 3 with Paget's disease. Of the 17 patients, 12 were transfers from other institutions and only 5 were direct admissions without a previous neuropsychiatric evaluation.
- 3. Skull changes of the hyperpituitary type were encountered in almost one-half of direct admission psychotics but only in one-fifth of an equal number of nonpsychotics. Hypogonadism was occasionally associated with the hyperpituitary type. The hypopituitary and hypothyroid types constituted a small minority.
- 4. Important findings are detected often enough to make skull screening in psychiatric hospitals worthwhile.
- 5. It is hoped that the frequently discovered hormonal disturbances can be related to the psychosis in some patients with subsequent benefit from specific endocrine management.

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We are indebted to Meyer A. Halperin, M.D., Staff Physician, Northport VA Hospital for his advice on endocrinologic features. The illustrations were prepared by Theodore H. Willers, Chief, Medical Illustration Service VA Hospital, Northport, New York.

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# LIPOID PROTEINOSIS—A NEW ROENTGENOLOGIC ENTITY\*

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ALTHOUGH the roentgenographic signs of lipoid proteinosis are pathognomonic and are easily recognized, there has surprisingly been no mention of this entity in the American radiologic literature.

#### CLINICAL DESCRIPTION

Lipoid proteinosis (lipoidosis cutis et mucosae) is a chronic disease consisting of hyalinosis and lipid deposits in the dermis, oral mucosa, and larynx.<sup>3</sup> Because of laryngeal involvement, victims are characteristically hoarse from infancy on, and progression may result in obstruction necessitating tracheostomy. This is the only potentially lethal aspect of the disorder.

Other manifestations are chiefly dermatologic. The face is pockmarked, and the skin is injured easily, with plaques and hyperkeratotic nodules forming on the elbows and knees. Sites of trauma are often marked by shallow ulcers. There may be nodular lesions on the eyelids, and verrucous lesions on the lip margins, axillae and gluteal cleft. Nodular lesions also involve mucous membranes of the mouth, pharynx, larvnx, vagina, and anal canal.

More complete clinical<sup>1,5,10</sup> and histochemical<sup>4,9,11,12</sup> descriptions have been published, with slightly over 100 cases now known.

# ROENTGENOGRAPHIC FINDINGS

An informed clinician can make the diagnosis of lipoid proteinosis from the clinical manifestations, but the diagnosis can also be made by the radiologist from skull roentgenograms.

Characteristic intracranial calcifications have been discovered and reported in many cases. 1,2,6,7,8 Our example, a case previously reported by McCusker and Caplan,6



Fig. 1. Characteristic intracranial calcification projected in the medial aspect of each orbit. (With permission from the *Am. J. Path.*)

showed typical findings. Two symmetric calcific densities shaped somewhat like inverted commas were seen lateral to and just above the dorsum sellae, each projecting in the medial aspect of the orbit in frontal view (Fig. 1 and 2). These did not have the appearance of either dural or carotid calcification, and were most likely within the temporal lobes approximately in the hippocampal regions. More exact localization will have to await air studies or autopsy find-



Fig. 2. Typical calcification adjacent to the dorsum sellae.

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ings, neither of which have been reported. Thus far, air studies have not been felt clinically warranted in this rather benign condition.

The significance of this intracranial calcification is unknown. Mental retardation and epilepsy have been described concurrently with this roentgenographic finding in some patients.3 The frequency with which the calcification occurs is also uncertain since a good share of the cases have not had skull roentgenograms made, but Scott and Findlay8 report positive findings in 7 of their 9 cases which had skull roentgenograms.

#### SUMMARY

A brief description of a disorder known as lipoid proteinosis has been presented, with introduction to the American radiologic literature of the pathognomonic roentgenographic findings.

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# SKELETAL ABNORMALITIES ASSOCIATED WITH GONADAL DYSGENESIS\*

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Gonadal dysgenesis is the diagnostic term applied to a group of patients who have hypoplastic or aplastic gonads and female external genitalia 13,15,23 in association with one or more of the following characteristics: primary amenorrhea, minimal secondary sexual development, short stature, increased pituitary secretion of follicle-stimulating hormone, a negative cellular chromatin pattern and a total chromosome count of 45 (XO).

Associated skeletal abnormalities have been noted by many authors<sup>4,6,12,13,19,20,22,24</sup> <sup>30,31,32</sup> and our study confirms the high incidence of epiphyseal dysplasia and osseous deformities. The patterns of osseous deformity in the hands, wrists, knees, and spines of 33 patients have been analyzed for their value as an aid in the roentgenographic diagnosis of gonadal dysgenesis (Table 1).

Diagnostic difficulties are increased by the lack of a constant clinical pattern in this genetic syndrome and by a multitude of diagnostic terms applied in previous years. The clinical picture shows much variation. Indeed, some patients appear entirely normal and others show gross abnormalities. <sup>14</sup> In infancy, edema of the extremities and webbing of the neck may suggest the diagnosis. <sup>26</sup> Older children are brought to medical attention because of dwarfism, amenorrhea, or failure to develop normal breasts, pubic hair, and other stigmata of sexual development.

# TERMINOLOGY

Gonadal dysgenesis was the name proposed by Grumbach, Van Wyk, and Wilkins<sup>11</sup> in 1955, when they recognized that these patients of female phenotype had

chromatin patterns at variance with those of normal women. Previous designations included Turner's syndrome, which has been widely applied since 1938, when Turner<sup>30</sup> described 7 girls with short, webbed necks, cubitus valgus, and sexual infantilism. Turner's syndrome has been extended by clinical usage and is often used synonymously with gonadal dysgenesis. The Bonnevie-Ullrich syndrome has been applied to young children with webbed necks, extremity edema, short stature, cubitus valgus, and deformed toes.<sup>23,28</sup>

Ovarian agenesis was suggested by Wilkins and Fleischmann, 33 in 1944, when they demonstrated vestigial streaks in place of ovaries without evidence of germinal epithelium or primordial follicles. In 1942, Albright, Smith, and Fraser described the elevated values for urinary gonadotropins in patients with ovarian insufficiency and decreased stature. Hypergonadotropic infantilism has been used as a diagnostic term to emphasize the diagnostic value of elevated urinary gonadotropins in patients with gonadal dysgenesis. 20,22,34

Thus, it is clear that gonadal dysgenesis is used to cover a wide variety of clinical and genetic patterns of disease. Subdivisions of this group of patients will be necessary as more information becomes available and may be facilitated by patterns of skeletal abnormality.

# CLINICAL AND GENETIC PATTERNS

It is well to emphasize again that in the literature on gonadal dysgenesis patients are included who are entirely normal in appearance, but who have the chromosomal abnormalities of gonadal dysgenesis. Indeed, Hoffenberg and Jackson<sup>14,15</sup> empha-

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Presented at the Sixty-second Annual Meeting of the American Roentgen Ray Society, Miami Beach, Florida, September 26–29, 1961.

 $T_{\rm ABLE~I}$  skeletal lesions in gonadal dysgenesis

No.	Chronological Age Skeletal Age	Nucle <mark>a</mark> r Chromatin	Elevated Urinary Gonadotropins	Height	Metacarpal Sign		Osteo-	Dysgenesis				
					Right	Left	porosis	Knee	C-1	Wrist	Spine	Foot
I	17/12	- (XO)	+	55	+	+	+	+	+			
2	15/13.5	_	+	52	+	+		+	+			
3	24/17	_	+	57	+	+	+	+	+		+	
4	16/11.5	_	+	49	+	+	+	+	+	+		
5	26/15	- (XO)	+	55	+	+	+	+	+	+		
6	15/12.5	-	+	53	+	+	+	+	+			
7	19/14.5	- (XO-XX)	+	56	+	_	+	+	+	+	++	
8	17/15	_	+ + + + +	52	_	_	+	+	++++		+	
9	17/13	_	+	54	+	+	+		+	+		
10	15/11	_	+	52	. —	_	+	+		+		+
ΙI	14/14	- (XO)	+	50	_	+	+	+		+	+	
12	16/12	- (XO-XX)	+	51	+	+	+					+
13	18/14	_	+	54	_	+	+	+	+	+	+	+
14	17/13	- (XO)	+	54	_	_	+	+	+			
15	15/12	- (XO)	+	54	+	_	+	+		+	+	++
16	17/13	- (XO-XX)	_	56	+	+		+	++	+	+	+
17	16/14	_ `	_	46	+	В	+	+	+			
18	23/18	_	+	53	_	+	+	+		+		+
19	16/14	_	_	59	_	_	+			+	+	
20	50/18	- (XO)	_	56	В	-	+	+	+	+		
21	14/13	_	+	54	_	-						
22	6/5.5	- (XX-XX)	_	41	В	+		+			+	
23	6/4	_ `	_	43	_	_				+		
24	4/5.5	_	_	42	_	_						
25	0.5/0.5	_	_	24	+	+		+				
26	0.2/0.2	- (XO)	_	22	_	_						
27	10/9	_ ` ′	_	49	_	_		+				
28	7/5.5	-	_	40	_	+		+				+
29	15/13	+	_	59	+	+						
30	13/11	+(XO-XXX)	_	50	_	_				+		
31	14/12.5	+	-	55	+	+						
32	24/17	+ (XX)	+	57	В	_	+	+	+	+		
33	20/17	+	+	51	В	В	+	+		+		

size that tall patients or normal-appearing women with variants of this syndrome can be explained by postulating three closely-linked genes for sexual infantilism, short stature, and miscellaneous abnormalities (musculoskeletal, cardiovascular, etc.). They conclude that the defects are not always inherited together.

Nevertheless, the diagnosis can be suspected clinically in patients of female phenotype, who are of short stature with sexual infantilism and amenorrhea (Fig. 1 A and 2A). Webbed neck, shield-like chest with widely spaced nipples, and edema are clinical findings of importance.<sup>2,7,12</sup> The diagnosis can be suspected in the newborn<sup>23,26,27</sup> who has female external genitalia and firm nonpitting edema of the hands and feet, with or without webbing of the neck.

Elevated urinary gonadotropins<sup>3,8,22</sup> are extremely helpful in the diagnosis of older patients who are seen with amenorrhea and failure of development of secondary sexual characteristics. Of particular diagnostic aid is the fact that elevated urinary gonadotropins appear during the second decade in patients with gonadal dysgenesis and are not found in patients with gonadal failure secondary to anterior pituitary hypofunction.

The most helpful laboratory aids have been the demonstration of abnormal chromatin patterns and actual chromosome counts. In 1949, Barr and Bertram<sup>5</sup> showed that the chromosomal sex of a somatic cell could be determined by the presence of a distinct mass of chromatin in most of the nuclei in females. This "sex chromatin" was very seldom found in the nuclei of



Fig. 1. Patient No. 14. This 17 year old Negro girl was 54 inches tall. (A) Photograph shows slight webbing of the neck and poorly developed breasts. Note the clinically evident cubitus valgus.

males. Since patients with gonadal dysgenesis show a lack of the chromatin bodies usually seen in females, they were at first thought to exhibit the male chromatin pattern. This misconception was clarified when true chromosome counts revealed the usual XO pattern of gonadal dysgenesis.

As previously indicated, the literature is confusing since no clinical or laboratory finding is constant for all patients with gonadal dysgenesis. 10,12,15,16,21,25,29,32 Nevertheless, significant patterns are evident

among the many variations. Although patients with male phenotype have been reported with gonadal dysgenesis, almost all patients have female phenotypes. Nine of 10 patients will have the negative sexual chromatin pattern. 11,12,22 Most patients will have the XO chromosome count, with 45 instead of the normal 46 chromosomes, although mosaics and other sex chromosome anomalies have been reported. 9,11,24

Table 1 lists many of the clinical and skeletal findings in our series. The last 5 patients were positive for nuclear chromatin. Chromosome counts have been obtained on 13 patients. They are XO (45 chromosomes) in 7 patients as in Figure 3; 5 patients showed a mosaic pattern—4 (XOXX) and 1 (XO-XXX)—and in the last, only cells of the XX pattern grew.

#### SKELETAL MATURATION AND GROWTH

Skeletal maturation is retarded in almost all patients with gonadal dysgenesis, al-

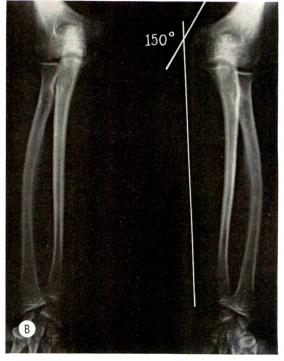


Fig. 1. (B) Roentgenographic study of the elbows shows no localized bone abnormality. The roent-genographic evidence of cubitus valgus was less striking than the clinical appearance.

though the deviation from normal is more prominent in older patients. This was emphasized by Acheson and Zampa, who noted that the deviation from normal in skeletal maturation was most prominent at the time when the patient should be adolescent. This accentuation of retarded skeletal maturation has been related to a deficiency of estrogen. <sup>19</sup>

In our patients with gonadal dysgenesis, almost all, as noted in Figure 4, showed a slight retardation in skeletal maturation. This finding was more prominent, however, in those over 14 years of age. The very young patients showed no demonstrable retardation of skeletal maturation.

Growth is generally retarded, and diminished stature in a girl is often the first clue to the diagnosis of gonadal dysgenesis. Nicolino<sup>22</sup> and others<sup>14</sup> have pointed out that these patients have diminished stature rather than true dwarfism, which can be defined as 20 per cent or more diminution from the ideal chronologic height.

Figure 5 shows the relation of height in our patients with gonadal dysgenesis to the average height for age. It is interesting to note that many of our older patients fall into the group between 54 and 58 inches in height. Hoffenberg and Jackson<sup>14</sup> have pointed out that the older patients with gonadal dysgenesis fall in this range. Note, however, that some of our patients are true dwarfs, and that none is above 5 feet in height.

This short stature is in striking contrast to the usual increased height of eunuchoid patients. Patients with gonadal dysgenesis do not show the increase in height and relative length of extremities usually seen in eunuchs. The reason is not known, but it is postulated that the less than average height is a genetic abnormality,<sup>25</sup> rather than a hormonal one.

### BONE MINERALIZATION

Many authors<sup>3,11–14,22,25</sup> have commented on the frequency of osteoporosis in patients with gonadal dysgenesis. In our experience, diminished mineralization of bone was



Fig. 2. Patient No. 20. This 50 year old Puerto Rican woman was 56 inches tall. (A) Photograph shows slight webbing of the neck and the classic shield chest with associated failure of normal breast development. Note the pronounced swelling of her left leg with chronic subcutaneous edema. There are many pigmented melanotic lesions in the upper half of the body.

most prominent in the older patient (Fig. 2, *B* and *C*). We recognize that deficient mineralization of bone is difficult to evaluate roentgenographically, but only 3 of 23 patients above the age of 15 failed to show roentgenographic evidence of low bone mineralization.

Our younger patients generally showed normal bone mineralization, although bone rarefaction, especially of the hands, feet, and elbows, has been described in children with gonadal dysgenesis.<sup>12</sup> Notwithstanding the fact that fractures are not frequent, the presence of blue sclerae in some of these patients has suggested a relationship with osteogenesis imperfecta.<sup>14</sup> One of our patients (No. 25, Table 1) had slightly blue



Fig. 2. (B) Roentgenographic study of the hand and wrist shows the Madelung deformity and the low level of bone mineralization.



Fig. 2. (C) Roentgenographic study of the knees shows the pronounced tibia vara-like deformity with particular prominence of the medial femoral condyle and beaking of the medial border of each proximal tibia.

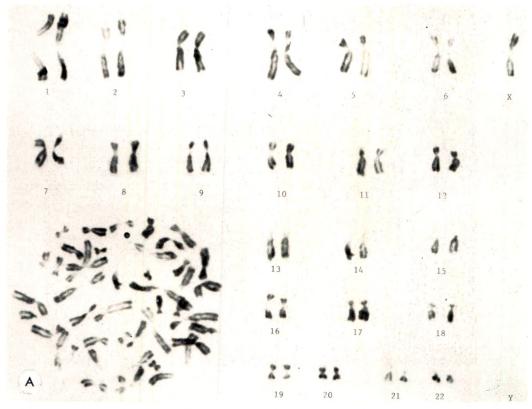


Fig. 3. Patient No. 5. This 26 year old patient was 55 inches tall. (A) Chromosome study of this patient showed 45 chromosomes with one X and no Y sex chromosome. Her nuclear chromatin was negative.

sclerae without other stigmata of osteogenesis imperfecta.

Deficient bone mineralization, since it is most prominent in the older patient, is usually explained on the basis of estrogen deficiency. However, this does not explain the deficiency of bone mineralization in younger patients, nor has there been significant improvement, in our limited experience, with hormonal therapy.

#### HANDS AND WRISTS

Patients with gonadal dysgenesis show a relative shortening of the fourth metacarpal. This can be recognized clinically by noting the relation of the lateral three knuckles in a closed fist. Normally, a ruler placed across the metacarpal heads IV and V will clear the third metacarpal.

Archibald, Finby, and DeVito<sup>4</sup> in 1959, described a roentgenographic sign for evaluation of the distal ends of the lateral

three metacarpals. This metacarpal sign is determined by drawing a straight tangential line across the distal ends of the fourth and fifth metacarpals. Normally, the continuation of this line passes distal to the distal end of the third metacarpal. When it crosses the third metacarpal, it is a *positive* sign.

In the entire population studied, a positive metacarpal sign was seen in 5.7 per cent of patients and 4.1 per cent of hands, more often in the left hand than the right. It may be a familial characteristic in normal women. However, a positive metacarpal sign was found more frequently in patients with gonadal aberration and delayed skeletal development. It is of interest that, although it is normal (negative) in patients with Klinefelter's syndrome, it is usually positive in patients with gonadal dysgenesis.

In our 33 patients with gonadal dysgene-



Fig. 3. (B) Frontal roentgenogram of the knees and forelegs shows the tibia vara-like deformity with depression and medial prominence of each proximal tibial epiphyseal area. Note the low level of bone mineralization and the relative elongation and bowing of the fibulae.



Fig. 3. (C) Roentgenogram of the hands shows a positive metacarpal sign bilaterally. There is a deformity of the wrist with marked angulation of the distal ends of the radii. There is an unusual fusion and tapering of the distal two phalanges in each of the four fingers of the left hand.

sis, a positive or borderline metacarpal sign was seen in 23, although it was unilateral in only 8 patients. As patients become older, the metacarpal sign becomes more positive, or shifts towards or to positive from a negative finding.

Metacarpal shortening is also seen in patients with pseudohypoparathyroidism. The association of gonadal dysgenesis with pseudo-pseudohypoparathyroidism has been noted by Van der Werff ten Bosch.<sup>32</sup> One of our patients (No. 8) had evidence of this association.

Wrist deformities, usually on the basis of epiphyseal abnormality, were seen in 16 of our 33 patients. The abnormalities varied from a mild flattening of the distal radial and ulnar epiphyses (Fig. 6, A–D) to marked flattening and shortening of the ulnar border of the distal radial epiphysis. This often resulted in a notched or V appearance at the wrist, with prominent sloping of the distal end of the radius, the shorter side being adjacent to the ulna (Fig. 6D). More advanced dysplasia is seen as Madelung's deformity<sup>19</sup> (Fig. 2, A, B and C).

Two patients (No. 4 and No. 33) had fusion of carpal bones (Fig. 6D) and one (No. 5) had an unusual fusion and tapering of the distal phalanges (Fig. 3C). One pa-

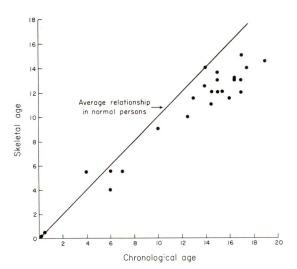


Fig. 4. Skeletal maturation in patients with gonadal dysgenesis.

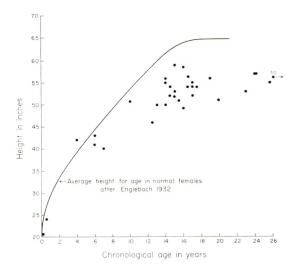


Fig. 5. Relationship of height to average height for age in patients with gonadal dysgenesis.

tient (Fig. 1A) was born with an incomplete distal phalanx of her left fifth finger. Other abnormalities included digital dysostosis and short middle phalanges in each fifth finger.

## KNEE DEFORMITY

When the hands of patients with gonadal dysgenesis were studied, it was noted that several of these patients exhibited an unusual symmetrical, tibia vara-like deformity of the knees. This was more prominent in older patients who did not have the clinical and roentgenographic features of the usual form of tibia vara or Blount's disease. Shortly thereafter we became aware of the work of Kosowicz, 17-19 who described a similar deformity of the medial tibial condyle as a frequent finding in his patients with gonadal dysgenesis.

The deformity consists of a medial and downward extension of the proximal portion of the tibia involving the epiphysis, which may be flattened, and the diaphysis, which may be beaked (Fig. 7, A, B and C). Occasionally, the medial condyle of the distal femur appears enlarged and displaced downward (Fig. 2C).

This tibia vara-like deformity of the knees has been carefully described by Kosowicz,<sup>17–19</sup> and later by Nicolino.<sup>22</sup> It has

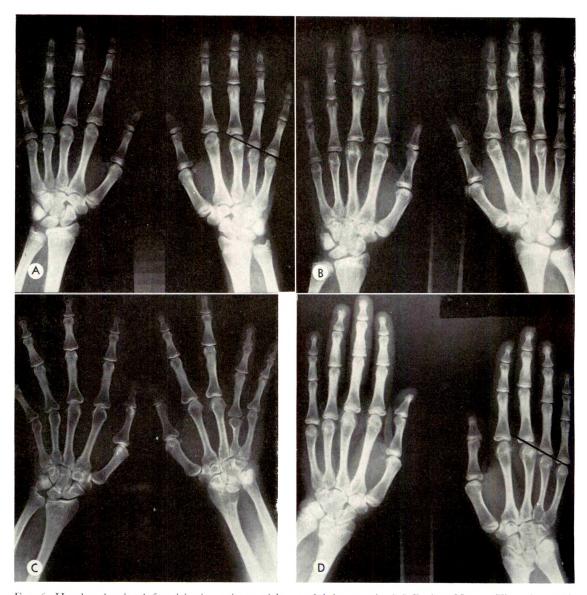


Fig. 6. Hand and wrist deformities in patients with gonadal dysgenesis. (A) Patient No. 29. There is a positive metacarpal sign bilaterally. The metacarpal line is drawn for reference on one hand. (B) Patient No. 9. There is a positive metacarpal sign bilaterally with minimal deformity of the distal radius and ulna at the wrist. Note the low level of bone mineralization. (C) Patient No. 18. There is pronounced shortening of the left fourth metacarpal with associated deformity of the left wrist. (D) Patient No. 4. There is a bilateral metacarpal sign with associated wrist deformities. Bilateral, symmetrical, partial fusion of carpal bones is also evident.

been called "anvil-shaped deformity of the upper tibia" and "superior tibial anomaly." We have described the symmetrical deformity as tibia vara-like and have seen this change in 23 of our 33 patients.

The very young patients do not show

significant deformity. The roentgenographic appearance of their knees is not markedly different from that seen in physiologic bowing of the knees in young children. Blount's disease or tibia vara is usually unilateral and commonly associated





Fig. 7. Knee deformity in patients with gonadal dysgenesis. (A) Patient No. 7. There is a moderate tibia vara-like deformity at the medial end of each tibia. (B) Patient No. 3. Similar tibia vara-like deformity of each knee with slight beaking of each medial tibial prominence. (C) Patient No. 1. Mild tibia vara-like deformity in both knees.

with genu varum or bowed legs. Bowing of the legs was not seen in our patients.

Kosowicz suggests that the knee deformity can be used as an aid in the diagnosis of gonadal dysgenesis. He studied 100 control patients with other endocrine disease as well as normal patients, and found no similar knee deformities. Our experience confirms these observations.

The deformity at the knees is probably part of the generalized epiphyseal dysplasia. However, the possibility of increasing deformity on the basis of osteoporosis and weight-bearing is suggested by the more prominent deformity in older patients and by the relatively high position of the proximal end of the fibula in many instances when the deformity is pronounced.

## CERVICAL SPINE

Webbing of the neck<sup>13</sup> is a characteristic of patients with Turner's syndrome,<sup>30</sup> and the Bonnevie-Ullrich syndrome.<sup>28</sup> Most of our patients showed short, broad necks (Fig. 14) without true webbing. The cervical spine was carefully studied, and there was no evidence of a Klippel-Feil abnormality or congenital fusion of the cervical vertebrae. These abnormalities, however, have been reported in other patients with gonadal dysgenesis.<sup>16,19,33</sup>

The only consistent abnormality in our series was a hypoplasia of the first cervical vertebra (Fig. 8, A and B). This was seen in 15 of our patients and may be of significance in this syndrome. In these patients, the first cervical vertebra appeared smaller

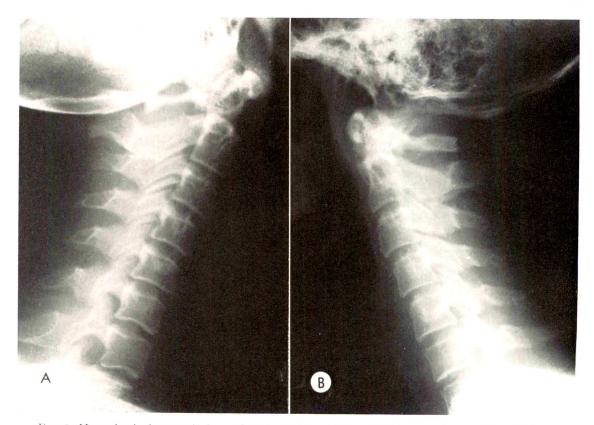


Fig. 8. Hypoplastic first cervical vertebrae in patients with gonadal dysgenesis. (A) Patient No. 9. (B) Patient No. 13.

and the posterior neural arch was thinner, and often incompletely fused. These changes were not found as often in normal patients of comparable age.

#### SPINE

Irregularity and fragmentation of the epiphyseal plates of the vertebral bodies were seen in 9 patients with gonadal dysgenesis (Fig. 9). This has been described by other authors<sup>2,3,8,16,19,25</sup> as epiphysitis or chondrodystrophy. Scoliosis, kyphosis, and spina bifida have also been reported in patients with gonadal dysgenesis<sup>7,13,19,25,29</sup> but were not prominent in our patients.

The vertebral changes are also part of the widespread epiphyseal dysplasia in patients with gonadal dysgenesis. These resemble the changes seen in Scheuermann's disease, but there is no kyphosis or round back deformity.

# OTHER SKELETAL ABNORMALITIES

Exostoses or osteochondromata were seen in 5 patients. These were isolated exostoses, usually located about the knee. It is noteworthy that the tibia vara-like deformity of the proximal tibia in our patients with gonadal dysgenesis occasionally resembled an exostosis (Fig. 2C and 7, A, B and C).

Although cubitus valgus was a prominent part of Turner's original description,<sup>30</sup> roentgenographic study of the elbow has not shown significant structural abnormality. The carrying angle is difficult to measure accurately and was not a reliable confirmation of the clinically evident cubitus valgus. For instance, a 17 year old Negro girl (Fig. 14) with a prominent cubitus valgus on clinical examination showed normal elbows roentgenographically.

Abnormalities of the feet are not com-

mon in patients with gonadal dysgenesis. Definite changes including short metatarsal bones and phalangeal deformities were seen in 7 of our patients. Several of these showed syndactyly and pedal edema. More serious structural abnormalities of the foot have been reported by others. 8,13,16,19

The only significant abnormalities of the skull demonstrated by our patients were related to the sella turcica. Two patients (No. 11 and No. 19, Table 1) had enlarged sellae and two (No. 2 and No. 7) had small pituitary fossae. Hypoplastic mandible, <sup>13,14,23,26</sup> <sup>29,33</sup> premature synostosis of sutures, <sup>23,29</sup> and abnormal sella turcica² have been reported in other series.

Many of our patients showed relative enlargement of the paranasal sinuses. This is of interest since hypogonadal hyperpituitarism may be associated with a thick calvarium and large paranasal sinuses.

No pattern of pelvic configuration could be determined since our observations were limited and many of the patients were quite young. Some female and male type pelves were observed. It is of interest that 3 patients showed a moderated degree of bilateral protrusio acetabuli.

## SUMMARY

- I. Thirty-three patients with gonadal dysgenesis were studied for patterns of skeletal abnormalities.
- 2. A positive metacarpal sign (relative shortening of the fourth metacarpal) was seen in 23 of the 33 patients, although it was unilateral in 8 patients.
- 3. A characteristic tibia vara-like deformity of the knees was seen in 23 of the patients and was more prominent in the older patients.
- 4. A hypoplastic appearance of the first cervical vertebra was seen in 15 patients. Less consistent variations were seen in the wrist, foot and spine.
- 5. Low bone mineralization was seen in 20 patients and was more prominent in the older patient.
  - 6. The osseous abnormalities are evi-

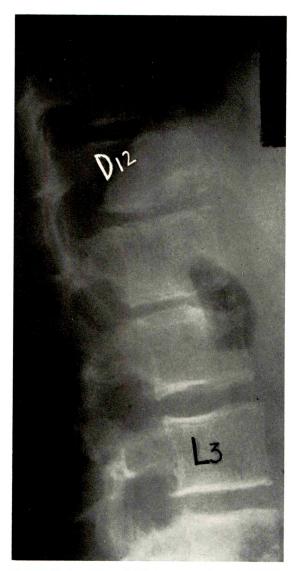


Fig. 9. Patient No. 16. There is marginal deformity of the vertebral bodies with associated thinning of intervertebral disk spaces. The roentgenographic appearance resembles that of Scheuermann's disease.

dence of a generalized epiphyseal dysplasia associated with osteoporosis and dwarfism. Genetic and hormonal factors are probably involved in the production of these variations

7. The combination of a positive metacarpal sign, tibia vara-like deformity of the knee, Madelung's type dysplasia of the wrist, and hypoplasia of the first cervical vertebra is strong evidence for the diagnosis of gonadal dysgenesis.

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# STERNOCLAVICULAR ARTHRITIS IN PATIENTS WITH SCLERODERMA AND RHEUMATOID ARTHRITIS\*

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THE effects of rheumatoid arthritis and scleroderma on the bones and joints of the appendicular skeleton are well known. Nevertheless, only occasional inquiries and roentgenologic investigations have been made regarding sternoclavicular arthritis with these diseases. The present report is concerned with 3 patients with scleroderma and 7 with rheumatoid arthritis, all with sternoclavicular arthritis identified roentgenologically.

Two of the 3 patients with scleroderma were women, 33 and 35 years old, and the third was a 35 year old man. The first 2 had scleroderma for about 3 years, and the third was afflicted for about 10 years. Five of the patients with rheumatoid arthritis were women, 4 between 35 and 45 years of age and one 72 years of age. One male was 57 years old and the seventh patient was a 15 year old male who had what was presumed to be an initial episode of rheumatoid arthritis, although questions arose as to whether he might have ankylosing spondylitis because of low back pain as well as pain in his wrist and sternoclavicular joints. The 72 year old female had had rheumatoid arthritis for more than 20 years. One 36 year old female had juvenile rheumatoid arthritis beginning at 7 years of age. The other 3 women and the 57 year old man had had the disease for periods from 3 to 10 years.

All 10 patients had involvement of multiple joints, particularly those of the extremities. The vertebral column was spared in 8. Two had changes limited to the sacroiliac joints.

The sternoclavicular joints were examined by conventional roentgenography and laminagraphy. Even though these articula-

tions usually are seen adequately on the customary frontal and oblique projections, laminagrams are advantageous, in that better delineation of the arthritic changes described here is obtained. Such studies are almost essential in heavy patients, and often are superior in identifying early structural changes. Laminagraphy is best performed with the patient supine, and three cuts about half a centimeter apart are desirable.

The sternoclavicular joint is a double arthrodial structure, the bony components of which are the inferior portion of the convex head of the clavicle and the upper lateral concave notch of the manubrium, and the adjacent cartilage of the first rib. The articular capsule is heavier anteriorly than superiorly or inferiorly. An intra-articular fibrocartilaginous disk often divides the joint into two compartments. Synovial membrane is present over at least one articular surface. The clavicular head is covered by a fibrocartilaginous cap, which during childhood and adolescence presents a smooth convex appearance. At about 15 years of age, a secondary ossification center appears as an epiphyseal structure in proximity to the clavicular head. Prior to the appearance of this center, the sternal end of the clavicle often assumes a somewhat concave appearance, and some increased density of the subchondral bone may be present as well. From the age of 15 to about 25 years, this accessory plate varies considerably in configuration, presenting in some as a thin single structure and in others as fragments of calcified cartilage in close apposition to the clavicular head. The latter should not be mistaken for a pathologic change. After the age of 25 years, the clavic-

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ular head again becomes smooth and convex. The sternoclavicular joint space usually is about 3 or 4 mm. wide. Degenerative changes are frequent after the age of 30 and may be relatively severe after 50.2,11

#### OBSERVATIONS

The roentgenologic manifestations of sternoclavicular arthritis were similar in patients with rheumatoid arthritis and scleroderma. The earliest change was observed in a 33 year old woman with scleroderma of 3 years' duration and a 57 year old man with rheumatoid arthritis of 10 years' duration. This appeared as a mild flattening of the clavicular heads and a mild loss of subchondral bone. The joint spaces were slightly widened. In the latter patient there also was a circular rarefaction with a rather dense, thickened rim just lateral to the inferior aspect of the clavicular head.

Four patients had more advanced roentgenologic changes. One had scleroderma for a period of 3 years, and 3 had rheumatoid arthritis for periods of 5, 10 and 20 years, respectively. The clavicular heads of these patients were flattened and irregularly pitted. Some erosion of the articular surfaces of the sternal components of the joints was present, and the joint spaces were narrowed. Spotty increase in the density of the subchondral bone of the clavicular heads was noted in 2 patients. In I there was fragmentation of the inferior aspect of the right clavicular head with slight downward displacement of a small bony fragment as well as the other changes.

Advanced sternoclavicular arthritis was observed in the remaining 4 patients, I with scleroderma and 3 with rheumatoid arthritis. The joint spaces in all 4 were markedly narrowed and irregular. The sternal notches were deepened. In I patient there was actual downward invagination of the eroded clavicular heads into the sternal notches. The articular spaces were pitted, irregularly flattened and increased density of subchondral bone was noted. In 3 patients, I with scleroderma and 2 with rheumatoid arthritis, cyst-like rarefied foci with thin,







Fig. 1. (A) Laminagram of the sternoclavicular joint of a normal 14 year old male. A rhomboid fossa is present at the inferior aspect of the proximal clavicle. Note the smoothness of the clavicular head. (B) Sternoclavicular joints of a normal 17 year old male. The concavities in the clavicular heads are rather prominent. A moderately increased osseous density is seen in the subchondral area. (C) Sternoclavicular joints in a normal 23 year old male. The clavicular heads have resumed a convex configuration. Adjacent to the midportion of the right clavicular head is a slender linear calcification in the epiphyseal plate partially fused to the head.

sharply delineated calcific rims appeared in the proximal 2 cm. of the clavicle.

Pain in the sternoclavicular areas was infrequent, even in the patients with advanced arthritic changes. The pain was fairly severe in the 15 year old boy, and mild pain was elicited on pressure in 3 others.

Concomitant rarefactive changes at the

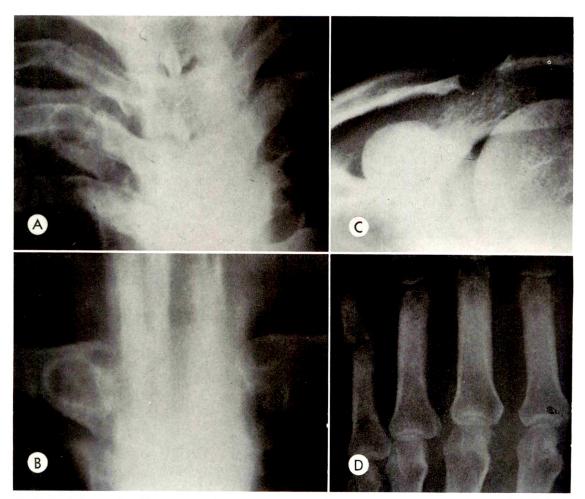


Fig. 2. (A) Conventional anteroposterior roentgenogram of the sternoclavicular joints of a 35 year old female with rheumatoid arthritis. Skeletal survey revealed involvement of the wrists, shoulders, ankles and knees. The clavicular heads are indistinct. A radiolucent focus is present in the head of the right clavicle. (B) Laminagram of the same patient. Radiolucent foci are present in the heads of both clavicles. Moderate subchondral bone resorption is present in the inferior aspects of both clavicular heads. Slight sclerotic changes are present in the upper portions of both clavicular heads. (C) Same patient. The acromial end of the clavicle presents a sharply demarcated erosive change. (D) Same patient. The arthritic changes involve the small joints of the hands, with destruction of the articular surfaces particularly prominent in the fifth proximal phalangeal joint.

acromial ends of the clavicles, such as those described by Alpert and Meyers, were noted in 4 patients, I with scleroderma and 3 with rheumatoid arthritis. These occurred in the most advanced cases, but were also observed in I patient who had mild arthritic alterations. Fusion of the manubriosternal joint was present in I patient with rheumatoid arthritis. This area was normal in 4 others, and was not examined in sufficient detail in the rest.

Associated arthritic changes in the peripheral joints, particularly those of the extremities, were extensive in the patients with rheumatoid arthritis. In these the changes were characterized by marked articular erosions and loss of bone in the ends of the small bones, flattening and distortion of the wrists, and rarefactive changes in the distal ends of the involved long bones. The peripheral joint involvement in the patients with scleroderma was less marked, but

other than in those with ungual tuft erosions and sharpened distal phalanges, could be interpreted as consistent with rheumatoid arthritis. In 2 patients with scleroderma, somewhat similar rarefied foci were observed in the clavicular heads, in the small bones of the hands and feet, and at the distal ends of the forearm bones.

Changes in the vertebral column which were limited to fusion of the sacroiliac joints were noted in 2 patients, I with scleroderma for a period of 10 years and the other a patient who had had rheumatoid arthritis for 20 years.

#### COMMENT

The pathologic changes occurring with rheumatoid arthritis and ankylosing spondylitis bear a striking resemblance to each other. The works of Cruickshank, 4 Savill, 9 Middlemiss, 8 and Gibson<sup>5</sup> bear out the concept of a common basic histopathologic pattern of synovial inflammatory changes, pannus formation and later bony fusion. It is generally agreed, however, that this does not indicate that the diseases are basically the same, even though some relationship cannot be excluded. Sokoloff<sup>10</sup> concurred with the concept that morphologic similarity did not necessarily imply common etiologic backgrounds or pathogenetic mechanisms. He reported synovial inflammation in scleroderma, and regarded chronic synovitis as an important manifestation of this disease, similar to that seen in rheumatoid arthritis, disseminated lupus erythematosus, and to some degree, rheumatic fever. He observed that the changes in scleroderma were milder than those seen with rheumatoid arthritis, but recognized the difficulty in distinguishing between these diseases purely on the basis of joint changes.

The roentgenologic changes described here correspond well with those which might be anticipated from the description of the pathologic changes of sternoclavicular arthritis in rheumatoid arthritis as reported by Sokoloff and Gleason.<sup>11</sup> These authors reported disappearance of the ar-





Fig. 3. (A) The sternoclavicular joint of a 34 year old female with scleroderma of more than 10 years' duration. There is subchondral resorption of bone, together with small circular rarefactions in the head of the right clavicle. Bony proliferation is present at the inferior aspect of the head of the right clavicle. The sternoclavicular joints are deeply indented, irregularly formed, and sclerotic changes are present along the sternal notch. The left sternoclavicular joint is fused. Arthritic changes also were present in the hands, ankles, knees and hips. Both sacroiliac joints were fused. There was extensive involvement of the skin, lungs and gastrointestinal tract. (B) Both hands of this patient revealed circular rarefactions in the small bones, particularly in the proximal phalanges. The joint surfaces were not grossly distorted.

ticular cartilages, replacement of the surfaces by compact collagenous and granulation tissue which had the characteristics of old pannus thrown up in coarse villous folds, forming a synovial type of lining. The articular surfaces were united at the margins by broad fibrous adhesions. The intraarticular disks had disappeared and scartissue had penetrated through large ulcerat-

ing defects in the subchondral plates of bone into the adjacent marrow. The vessels in the scar tissue near the involved joints were undergoing necrosis and their walls were impregnated with fibrin that extended also into the surrounding fibrous tissues.

All 3 patients with scleroderma had other articular involvement, particularly in the small joints of the hands and wrists. The extent of articular destruction was less advanced than that in the patients with rheumatoid arthritis. In addition, the rarefied lesions noted in the phalanges and in the distal ends of the forearm bones appeared to be more prominent than in the patients with rheumatoid arthritis. This is in accord with the changes reported by Beigelman, Goldner and Baylis.<sup>3</sup> Similar rarefactions were observed in the clavicular heads in our patients with scleroderma and rheumatoid arthritis.

Arthritic changes similar to those observed with rheumatoid and collagen diseases have been noted in the sternoclavicular joints in ankylosing spondylitis. Sternoclavicular arthritis also occurs with Reiter's disease, 2 gout, tuberculosis, osteomyelitis, syphilis, and relatively often as a degenerative phenomenon. These usually can be differentiated from the changes associated with rheumatoid arthritis or scleroderma on the basis of concomitant clinical manifestations.

#### SUMMARY

Similar sternoclavicular arthritic changes were demonstrated roentgenologically in 3 patients with scleroderma and 7 with rheumatoid arthritis. The earliest change is slight flattening of the clavicular heads and slight subchondral bone resorption. Later manifestations are sclerotic and erosive

changes along the articular margins of the clavicular and sternal components of the joint, loss of the joint space and cyst-like rarefactions in the clavicular heads.

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# MULTIPLE MYELOMA OF THE CHEST WALL\*

By DONALD A. WOLFEL, M.D., and JOHN M. DENNIS, M.D. BALTIMORE, MARYLAND

THE roentgenologic manifestations of multiple myeloma have been well documented in the past by numerous authors. Little specific attention has been given, however, to myelomatous involvement of the chest wall which may masquerade clinically and roentgenologically as metastatic malignancy or primary pulmonary disease. We have had occasion to study 4 such patients in whom the chest wall lesion was the initial manifestation of multiple myeloma, and in whom the recognition of the nature of the roentgen abnormality led to a correct diagnosis.

#### REPORT OF CASES

CASE I. J.T., a 75 year old white male, first experienced right chest pain and a cough productive of copious sputum 3 months prior to hospitalization at the University of Maryland Hospital. The patient had been hospitalized elsewhere where a diagnostic work-up failed to reveal the nature of an apparent mediastinal mass. Roentgen studies here demonstrated a soft tissue mass involving the right posterior chest wall with partial destruction of the posterior third of the sixth rib (Fig. 1, A, B and C). Myeloma was felt to be the likely diagnosis, although no bone lesions were found elsewhere. Biopsy of the lesion and aspiration of the sternal marrow revealed myeloma.

Case II. R.P., a 56 year old white female, developed an acute respiratory infection which was followed in 3 weeks by fever, severe right chest pain and dyspnea. Roentgen studies of the chest elsewhere at that time were thought to reveal a bronchogenic carcinoma. The patient was then admitted to the University of Maryland Hospital, where an admission roentgenogram of the chest demonstrated a destructive lesion and a pathologic fracture in the right seventh rib posteriorly and an associated extrapleural mass (Fig. 2, A, B and C). On the basis of the rib lesion and the extrapleural mass,

a roentgenologic diagnosis of myeloma was made. Bone survey, however, revealed no other bone lesions at that time. Biopsy of the right seventh rib and a sternal marrow biopsy both confirmed the diagnosis of myeloma. The disease finally became generalized and the patient died one year later.

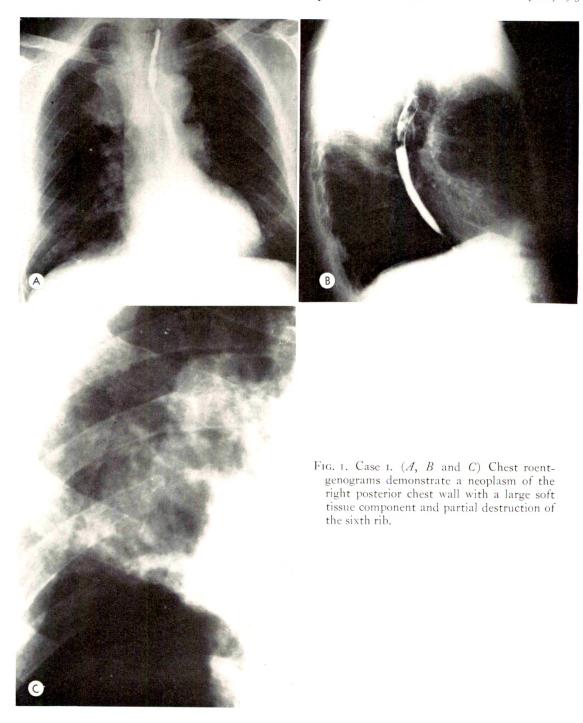
CASE III. F.M., a 57 year old Negro female, was hospitalized for elective surgical repair of a urethral diverticulum containing a calculus. A routine chest roentgenogram revealed a neoplasm of the right chest wall with destruction of a portion of the right fifth rib (Fig. 3, A and B). Symptoms referable to the lesion could not be elicited from the patient. No other skeleta! lesions could be found by roentgen studies. Excision biopsy of the chest wall neoplasm and rib confirmed the suspected roentgenologic diagnosis of myeloma. Sternal marrow aspiration showed an abnormal number of plasma cells, compatible with the diagnosis of myelomatosis. The patient died of disseminated myeloma 15 months later.

Case IV. H.S., a 65 year old white male, was admitted to the surgical service for repair of an inguinal hernia which had incarcerated on several occasions during the previous 3 years. A preoperative roentgen study of the chest revealed a destructive lesion of the anterior margin of the left sixth rib and an associated localized soft tissue mass thought to be myeloma (Fig. 4, A and B). Bone survey disclosed no other bone lesions. A segmental resection of the anterior margins of the right sixth and seventh ribs confirmed the suspected diagnosis of myeloma. The patient was re-admitted 4 months later with widespread disease.

#### DISCUSSION

The frequent incidence of myelomatous involvement of the bony structures of the chest wall has been well established.<sup>3</sup> Tumors of the ribs, sternum, thoracic spine and clavicles have been estimated to

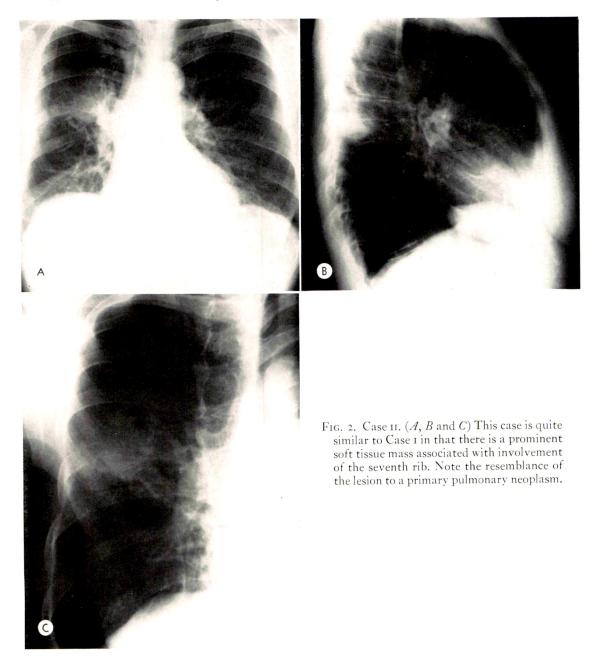
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be present in 70–90 per cent of patients with this disease, with the ribs the most common site of pathologic fracture. This apparent predilection in myeloma has prompted Geschickter and Copeland to regard a pathologic fracture of a rib in an

adult as presumptive evidence of myelomatosis.

Characteristically, a myelomatous tumor of the chest wall will possess a rather prominent associated soft tissue mass.<sup>4,5</sup> As the tumor extends inwardly, it forms a sub-



pleural mass, displacing the pleural layers from their usual location adjacent to the chest wall. The soft tissue component is often the most readily detectable portion of the lesion roentgenographically. It has been stressed by Williams<sup>4</sup> that the soft tissue tumor of a myelomatous chest wall lesion is greater or more conspicuous than that of a metastatic tumor to the chest wall.

Each will show rib destruction, but the metastatic process will possess little or no soft tissue mass. We would like to reemphasize this point, and offer it as a practical means of differentiating between myeloma and metastatic malignancy of the chest wall

It is of interest to note that in each of the 4 cases presented the chest wall tumor

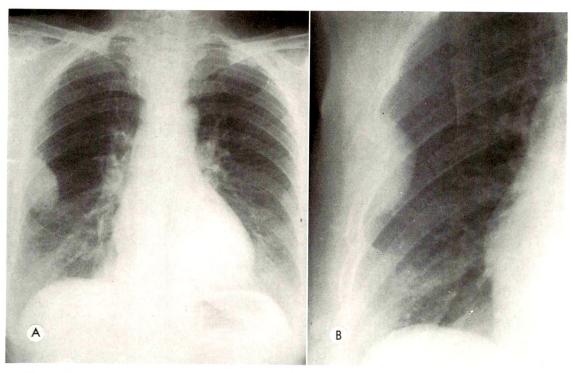


Fig. 3. Case III. (A and B) Routine chest roentgenograms show a neoplasm of the right chest wall, with rib destruction and a prominent soft tissue mass, characteristic of myeloma.

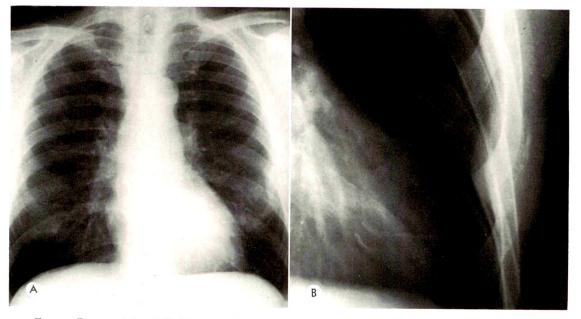


Fig. 4. Case iv. (A and B) Preoperative chest roentgenograms reveal an osteolytic process of the left sixth rib with a localized extrapleural soft tissue mass.

was the initial manifestation of generalized myeloma. In 2 of the patients the lesion caused no symptoms, having been found incidentally. The other 2 patients had local pain referable to the site of the tumor, as well as clinical evidence of pulmonary infection. In each of these latter patients, the resemblance of the myelomatous process to pulmonary and mediastinal pathology led to an initial erroneous roentgenologic diagnosis elsewhere.

#### SUMMARY

Multiple myeloma may be differentiated roentgenologically from metastatic malignancy involving the chest wall by recognition of the prominent soft tissue mass accompanying the myelomatous osseous lesion. Four cases are presented in which this finding allowed a correct roentgenologic diagnosis. In 2 instances the chest wall le-

sion simulated pulmonary and mediastinal neoplasm.

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# DYSFIBROPLASIA OF BONE\*

By NILS P. G. EDLING, M.D. STOCKHOLM, SWEDEN

KNOWLEDGE of existing variations in both the signs and sites of a disease process is a prerequisite for its accurate diagnosis, as is the awareness that a tissue or an organ responds according to its structure when subjected to diverse influences. These facts are strikingly illustrated by the fibrous changes that may occur in bone due to developmental errors, hyperparathyroidism, or trauma.

McWhirter<sup>5</sup> has emphasized the similarities in the radiolucent bone changes observed in bone cysts, osteitis fibrosa, and the so-called giant cell tumors. Because, instead of bone, fibrous tissue containing no calcium is deposited, he suggested that these lesions originate as a result of errors during the complex development of bone at the epiphyseal plate and proposed the term "dysfibroplasia" so as to include them as variants of the same process. The histologic findings are essentially determined by the vascularity of the location of the lesion; the location is dependent on the stage at which the disturbance in development at the epiphyseal plate occurs.

A dysfibroplastic change which occurs early in life is one in which fibrous tissue migrates away from the epiphyseal plate as growth continues and eventually, at the cessation of growth, becomes situated in the diaphyseal portion of the bone. Due to the meager vascularity of the compact shaft of the long bones, the fibrous component usually undergoes fluid degeneration, and a bone cyst develops. A dysfibroplastic change occurring at the period of epiphyseal fusion is manifested in spongy bone at the epiphyseal area and may acquire an expanding character in that portion of the bone which is relatively richly vascularized. The blood vessels in the fibrous area lack the interstitial support normally present in bone and become dilated, possibly resulting

in clinically perceptible pulsations. Bone trabeculae, eroded by the dilated vessels, and hemorrhages stimulate the formation of foreign body giant cells, and the typical signs of giant cell tumor are then noted but with no evidence of a true neoplastic process. Finally, if a dysfibroplastic change develops between these extremes of position, i.e., in the metaphyseal portion of the diaphysis, the fibrous component usually remains unchanged since the vascularity is sufficient to prevent cystic degeneration but insufficient to produce erosion of trabeculae and hemorrhages with formation of giant cells. The lesion is then called osteitis fibrosa, or fibrous dysplasia.

Because the vascularity of the location of the lesion varies with the age of the patient and due to differences between individuals, the dysfibroplastic manifestations may occur outside the usual areas of incidence and may be histologically intermingled. Strict diagnostic classification, particularly in border-line cases, becomes difficult for the pathologist indicating similarity of these changes.

Dysfibroplastic lesions similar to the above variants are also found in hyperparathyroidism. Although there may be differences in the bony manifestations of hyperparathyroidism, there is no doubt that the cause is identical—an excess of parathormone. It is important to note that bone cysts, osteitis fibrosa, and the so-called giant cell tumors found in hyperparathyroidism have essentially the same localizations as in developmental errors, again supporting the suggestion that the varying appearances of a dysfibroplastic process in bone are the result of differences in the state of vascularization of that part of the bone in which they are situated. The changes found in hyperparathyroidism are also detected in bone developed in membrane

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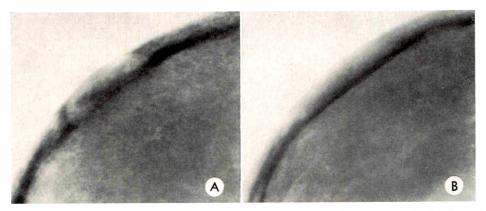


Fig. 1. Dysfibroplasia in hyperparathyroidism. Female, aged 59. (A) Cystic defect in the frontal bone. (B) Ossification  $4\frac{1}{2}$  months after parathyroidectomy.

(Fig. 1, A and B).

A third etiologic agent, trauma, may produce bony disorders of a dysfibroplastic nature. The skeletal parts most often exposed to trauma are the areas most frequently affected, such as the fingers and toes and in the case of football players, the anterior aspect of the tibia. These changes may be observed at any age and roentgenographically range from a simple cyst to expanding outgrowths (Fig. 2, 3 and 4).

The presence of a dysfibroplastic lesion indicates a circumscribed insufficiency in

bone formation with derangement of bone production.

In developmental errors at the epiphyseal plate, it seems that the mesenchymal cells have not achieved their specialized task as osteoblasts and are able only to form fibrous tissue. This concept of a primary affection of bone formation at the epiphyseal plate is supported by the production of the changes in parts of bone developed in cartilage, while bone developed in membrane appears uninvolved. Further support is the coincident shortening or deformity of



Fig. 2. Dysfibroplasia, probably due to trauma. Male, aged 61. Large radiolucent areas in the mid-phalanges of the second and fifth digits and marked deformity and lucent areas in the epiphyses at the interphalangeal joints. No clinical signs of rheumatoid arthritis.

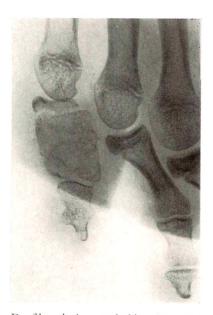


Fig. 3. Dysfibroplasia, probably due to trauma. Male, aged 16. Expansion and indistinct bony architecture of the promixal phalanx of the right fifth toe; the epiphysis is fairly normal. Biopsy after resection showed highly vascularized fibroblastic tissue with hemorrhage and foreign body giant cells as well as areas of osteoid and cartilaginous tissue.

the related bones, as well as the occurrence of cartilage in giant cell tumors (Codman, 1931) and in polyostotic fibrous dysplasia (Hobaek, 1951). Areas of cartilaginous and osteoid tissues were found in the case of dysfibroplasia shown in Figure 3.

Hyperparathyroidism is of special interest since the parathyroid hormone controls osteoclasis. The predominant skeletal abnormality in this disease is generalized osteoporosis, which may be associated with circumscribed dysfibroplastic areas. Osteoporosis is caused by an increased osteoclastic activity that overshadows new bone formation by the osteoblasts, with reduction of trabecular thickness and number, the remaining structure of the trabeculae being unchanged.<sup>1,3</sup> There is little evidence supporting the view that calcium is removed in any other way than by the activity of the osteoclasts. The dysfibroplastic areas suggest an intense localized osteoclasis with an insufficiency of osteoblastic activity rather than production of new osteoid tissue and deposition of calcium salts, as only fibrous tissue is formed. The manner of the initiation of this process by the parathyroid hormone is at present obscure. The immediate relationship of the dysfibroplastic lesion to the parathyroid hormone is also demonstrated by the fact that there is resumption of bone formation when the hormone excretion is restored to a normal level after parathyroidectomy (Fig. 1, A and B; and 5, A and B).

Disturbance of blood supply or bone architecture may be a causative agent in the development of dysfibroplastic changes incident to trauma. Here again, bone cell activity is disorganized.

Contrary to the beliefs of Jaffe<sup>2</sup> and Lichtenstein<sup>4</sup> most pathologists feel that the dysfibroplastic bone changes due to developmental errors, hyperparathyroidism, and trauma cannot be histologically segregated. Giant cell tumors are included in this histologic category, suggesting that they are similar and not true tumors. In addition, Jaffe<sup>2</sup> states that bone cysts may be impossible to distinguish histologically from



Fig. 4. Subperiosteal expanding dysfibroplasia, probably due to trauma. Female, aged 53. Trauma to dorsal right metacarpal area incurred in a fall in childhood. Subsequently a dorso-ulnar bulging in the distal fifth metacarpal developed. No progressive growth.

aneurysmal bone cysts. Often, the differentiation of an aneurysmal bone cyst and a giant cell tumor may only be made roentgenographically when the location of the lesion with reference to the epiphyseal plate can be determined.

The division of dysfibroplasia of bone into different pathologic entities as described in many textbooks according to appearance and location is confusing (fibrous cortical defects, solitary bone cyst, fibrous dysplasia, osteitis fibrosa, aneurysmal bone cyst, giant cell tumor, osteoclastoma, etc.). The clinical classification and diagnosis of

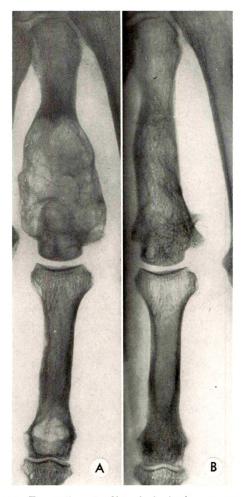


Fig. 5. Expanding dysfibroplasia in hyperparathyroidism. Female, aged 51. (A) Changes localized to the third metacarpal and proximal phalanx of the left third digit. (B) Ossification and marked decrease in deformity 1 year after parathyroidectomy.

these abnormalities would be enhanced if the lesions with dysfibroplastic changes were grouped together. The type of a lesion is basically dependent upon its localization, i.e., whether in spongy or compact bone and the degree of vascularization which is present. Dissimilar etiologic factors may result in similar manifestations.

The difficulty of including the so-called giant cell tumor in a dysfibroplastic grouping of similar bone lesions is eliminated if the presence of foreign body giant cells is regarded as a secondary reaction to a process in spongy bone with hemorrhage and bone debris. As is recognized, giant cells are usually found in bone processes in which there is considerable tissue destruction, and—as a strong evidence—particularly after an exploratory operation. If malignancy should really occur in such a change, it should be remembered that no tissue is immune from malignant degeneration. It is probable that in cases described as giant cell tumors with malignant change, an osteogenic sarcoma was initially present but because of the marked content of foreign body giant cells in the destructive tissues the case was misdiagnosed.

## SUMMARY

Dysfibroplasia of bone is discussed as a pathologic entity with varying manifestations. The non-neoplastic nature of the so-called giant cell tumor is emphasized.

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## OSTEOCHONDROSIS\*

#### A DESCRIPTION OF TWO UNUSUAL SITES OF INVOLVEMENT

By THEODORE E. KEATS, M.D., and PAUL C. WHEELER, M.D. COLUMBIA, MISSOURI

TWO patients are reported who demonstrated on roentgenograms unusual sites of involvement by aseptic necrosis. To our knowledge, no new description of these entities has appeared in the American literature in the past 35 years. It is, therefore, our purpose to bring these lesions to the attention of those who may not be familiar with them.

#### REPORT OF CASES

Case 1. This 10 year old white boy was admitted to the University of Missouri Medical



Fig. 1. Case I. Roentgenogram of the right shoulder showing evidence of osteochondrosis of the capital humeral epiphysis.

Center for evaluation of congenital dislocation of the hips. The physical examination showed some limitation of motion of the hips and right shoulder. Roentgenograms of the hips revealed old subluxations with deformity of the femoral heads. A roentgenogram of the right shoulder (Fig. 1) disclosed deformity of the capital humeral epiphysis and adjacent metaphysis. The medial portion of the epiphysis was flattened and prolonged medially and inferiorly. The medial aspect of the humeral metaphysis was somewhat overgrown as if to compensate

for the loss of height of the epiphysis. There was some fragmentation of the medial half of the epiphysis as well. The joint space was widened and the glenoid fossa irregular. A roentgen survey of the entire skeleton showed no evidence of other osseous abnormalities. The roentgenographic impression was osteochondrosis of the capital humeral epiphysis.

Case II. This 20 year old white woman was admitted to the University of Missouri Medical Center because of pain in the dorsum of the right foot of several months' duration. Physical examination showed slight swelling and tenderness in the dorsum of the foot over the talonavicular joint.

A roentgenogram of the right foot (Fig. 2) showed the classic changes of osteochondritis dissecans of the tarsal navicular bone, manifested by the presence of a dense button of bone lying in a radiolucent fossa which, in turn, was surrounded by a band of osteosclerosis. The patient was treated conservatively by support of the longitudinal arch with resultant relief of symptoms. A follow-up roentgenogram made 9 months later showed no change.

#### DISCUSSION

Primary aseptic necrosis or osteochondrosis of the capital humeral epiphysis in the growing skeleton is an uncommon localization in this disease. Osteochondritis dissecans of the articular surface of the humerus or aseptic necrosis following trauma is seen later in life and is not the same entity described here. The osteochondrosis with which we are concerned is an aseptic necrosis of the primary growing ossification center of the humeral head.

We have been able to find only 2 reports of similar cases, the first by Haas<sup>1</sup> in 1921 and the second by Lewin<sup>2</sup> in 1927. The similarity between these previously re-

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ported cases and those described here is striking.

The changes in the humerus resemble those of Perthes' disease of the hip and more particularly Blount's disease of the medial tibial plateau, and it is our belief that the pathogenesis is similar. Haas's case was associated with Perthes' disease of the hip. Lewin's patient had a birth palsy of the involved upper extremity and he suggested that perhaps forceable stretching movements associated with physiotherapy may have contributed to the osteochondrosis. Case I also had bilaterally subluxed hips, one of which had been operatively reduced. It is suggested that perhaps the occurrence of osteochondrosis in this location may be associated with trauma of manipulation as in Lewin's case or with the excessive use of the upper extremity as in a child who is confined to bed or who uses crutches.

Osteochondritis dissecans of the tarsal navicular bone must be differentiated from the more common osteochondrosis of this bone (Köhler's disease). In the latter the entire bone is involved in contrast to the articular surface involvement in the former. We have been able to find only 2 other references to osteochondritis dissecans of the tarsal navicular bone, both in the German literature.3,4 It is interesting that in both of these cases, the area of involvement was on the distal articular surface of the navicular bone, whereas in our Case II, the proximal articular surface was affected. The typical dense fragment of bone was seen lying in a fossa in the articular surface of the navicular bone.

The tarsal navicular bone is an uncommon site of involvement for osteochondritis dissecans, although it frequently undergoes aseptic necrosis of its primary ossification center in the growing skeleton or following trauma in the adult. Osteochondritis dissecans is most commonly seen in the distal femoral condyles, the head of the femur, the distal articular surface of the tibia, the elbow, and the proximal articular surface of the humerus. Osteochondritis dissecans of

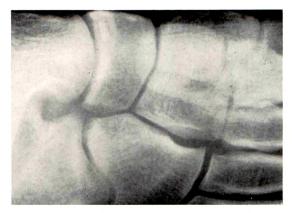


Fig. 2. Case II. Roentgenogram of the right foot showing classic appearance of osteochondrosis dissecans of the proximal surface of the tarsal navicular.

the humeral head should be differentiated from the form of aseptic necrosis described in Case 1.

In reviewing the literature on this subject, we have found considerable confusion in terminology. We share the opinion that this entire group of diseases resulting from aseptic necrosis should be entitled the osteochondroses. The term osteochondritis should be abandoned since it suggests a primary inflammatory component which probably does not occur. The term osteochondritis dissecans (or more appropriately osteochondrosis dissecans) should be reserved for that form of the articular surface aseptic necrosis which is probably the result of a localized area of infarction of bone. Pathologically, there is found a button of necrotic bone which becomes separated from the articular surface. The findings in Case II are clearly of this variety. Osteochondrosis dissecans is almost invariably found in adults, whereas aseptic necrosis of primary ossification centers is a disease of the growing skeleton.

#### SUMMARY

Two patients with unusual sites of involvement of osteochondrosis have been described. The first of these showed aseptic necrosis of the primary ossification center of the head of the humerus. The second

case showed typical osteochondrosis dissecans of the proximal articular surface of the tarsal navicular bone. These lesions should be differentiated from the more common forms of osteochondrosis which affect the same bones. A suggested nomenclature for this group of diseases is offered.

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# INVOLVEMENT OF THE CARPAL BONES WITH METASTATIC TUMOR\*

By RICHARD J. SMITH, M.D. BOSTON, MASSACHUSETTS

METASTATIC malignant disease is known to occur in the bones of the hands. Over 30 cases have been reported with evidence of secondary malignant involvement of the phalanges and the metacarpals. However, only 2 cases are on record describing metastatic foci to the carpal bones. An additional case of metastatic disease to the carpus thus appears worthy of attention.

#### REPORT OF A CASE

The patient (C.M.G. #115269) was a 41 year old white male who was referred to our hospital on August 24, 1961 with an 8 month history of mid-back pain of gradually increasing severity.

The patient had been a shoemaker and reported that he had smoked "a couple of packs" of cigaretts a day for over 20 years. He stated that he had suffered with "frequent bad colds" for 6 or 8 years. These were accompanied by a dry cough. There was no history of hemoptysis.

In April, 1961, 3 months after the onset of back pain, the patient noted a dull, steady ache in his right hip, with radiation of the pain into

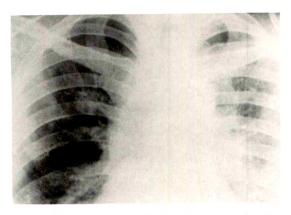


Fig. 1. Roentgenogram of the chest made in August, 1961 showing a right hilar and upper mediastinal mass confluent with a 3 cm. rounded density in the right lung parenchyma. There is increased density in the left hilus.



Fig. 2. Premortem roentgenogram of the right hand which was originally interpreted as showing metastatic disease to the lesser multangular bone. The radiolucent regions noted in other carpal bones were not thought to represent metastatic foci.

the right calf. He was treated symptomatically and then was referred to us for hospitalization in August, 1961.

When he entered the hospital, the patient appeared gravely ill. In addition to his back and hip pain, he complained of the recent onset of mild, steady aching in the back of his right hand. The ulnar side of the anatomic snuffbox was tender to deep pressure. The hand was neither hot, red nor swollen. The wrist and digits moved through a full and painless range of motion.

Roentgenograms revealed a right hilar and upper mediastinal mass confluent with a 3 cm. rounded density in the right lung parenchyma. There was increased radiodensity in the left hilus (Fig. 1). Osteolytic lesions were present in the right femur, pelvis, scapula, humerus, seventh, eighth and ninth ribs and the cranium. Roentgenograms of the right hand were reported as showing evidence of marked osteolysis of the right lesser multangular bone (Fig. 2).

 $<sup>*\</sup> From\ the\ Surgical\ Service,\ United\ States\ Public\ Health\ Service\ Hospital,\ Boston,\ Massachusetts.$ 

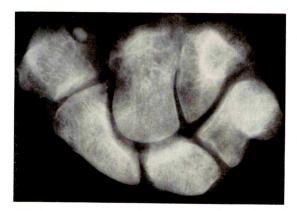


Fig. 3. Postmortem roentgenogram of the excised carpals of the right hand. Osteolytic areas are clearly seen in all carpals except the pisiform.

A biopsy of the right greater trochanter disclosed an adenocarcinoma—primary probably in the lung. The pulmonary lesion was considered inoperable and the patient was treated with radiation, uracil mustard and thiotepa. He died in October, 1961, 2 months after his admission to the hospital.

A postmortem examination revealed adenocarcinoma of the lung with metastases throughout the viscera and the skeletal system.

The 8 carpal bones of the right hand were removed at autopsy. There was no tumor in the soft tissue adjacent to the bones. The articular cartilage of each bone was intact. Although the premortem roentgenograms of the right hand had been interpreted as showing a lytic lesion in the lesser multangular bone only, postmortem roentgenograms of the excised carpals disclosed definite areas of radiolucency in all the carpals except the pisiform (Fig. 3).

On microscopic examination, the lesser multangular was seen to be almost completely replaced by tumor tissue (Fig. 4). Varying quantities of tumor tissue were found throughout all the other carpal bones except the pisiform. In none of the involved bones did the tumor cells break through the cortex. All osseous structures appeared viable. No osteoclasts were noted in areas of resorbing bone, and there was no evidence of an attempt at new bone formation.

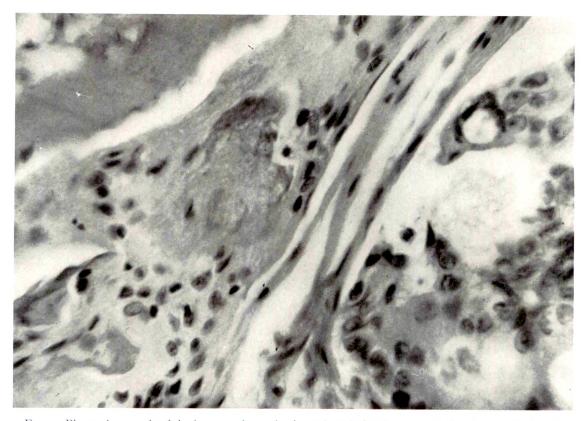


Fig. 4. Photomicrograph of the lesser multangular bone (40×) showing metastatic tumor cells almost completely replacing the bone.

#### PREVIOUS CASES

The 2 previously reported patients with metastatic disease to the carpals both died soon after disease was noted in the hand.

Case 4, described by Kerin, was a 62 year old female who complained of swelling over the lateral aspect of her right hand 5 vears after treatment for a breast carcinoma by right radical mastectomy. She died 2 months later with osteolytic lesions of her second and third metacarpals, navicular bone, capitate and greater and lesser multangulars. She also had a destructive lesion of the proximal half of her right femur. Biopsy of the metacarpal lesion had revealed metastatic adenocarcinoma. The published roentgenogram suggests that the lesion in the hand was growing by contiguity with cortical disruption of the involved carpal bones.

Vancura, Jakoubkova and Kolar<sup>2</sup> reported the case (Case 2) of a 64 year old male with a nonresectable left hilar bronchogenic carcinoma who developed swelling of his left hand 4 months after the discovery of his lung lesion. Roentgenograms of the hand were normal at the time of his

first complaints, but 3 weeks later showed an osteolytic lesion of the proximal half of the left navicular bone. The patient died 10 months later with evidence of extension of the pulmonary lesion, regional lymph node metastases and metastases to the crest of the ilium.

#### DISCUSSION

Subtle roentgenographic changes of density may be difficult to detect in the carpus due to overlapping bone and soft tissue shadows. This may account for the apparent predilection of the tubular bones as the site of metastatic disease to the hand. To be alert to the possibility that discrete carpal metastases may serve as a source of wrist or hand pain may permit an earlier diagnosis of this condition.

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## SYMPHALANGISM\*

By ENRIQUE SCHWARZ, M.D., and GIUSEPPE RIVELLINI, M.D.†

THE term "symphalangism" defines a rare hereditary and familial anomaly of the hands and feet which was first described by Mercier in 1838. The condition has been reported under various other names, such as congenital ankylosis or aplasia of the interphalangeal joints, phalangeal anarthrosis and hereditary multiple ankylosing arthropathy. The more adequate term of symphalangism was first adopted by Cushing. It denotes a partial or total absence of one or more interphalangeal joints with fusion of the ends of the adjoining phalanges and resulting stiffness of the affected finger or toe.

#### CLINICAL CONSIDERATIONS

Symphalangism is due to failure of differentiation of the interphalangeal joint which normally occurs during the eighth week of fetal life. This condition is hereditary and follows a simple dominant mendelian type of transmission. It has been traced through several generations of the same families<sup>2,3,6</sup> and has not been reported in the Negro race.

Symphalangism may occur in any or all of the interphalangeal joints of hands and feet. It affects the proximal interphalangeal joints more frequently, has never been reported to occur in the thumb, and rarely involves the fifth fingers. It is commonly present in the fifth toes of normal individuals. Various degrees of symphalangism may be present in the same person. It is often associated with other congenital anomalies such as pes planus, absence of the pectoral muscles, and synostosis of the carpal and tarsal bones.<sup>5</sup>

The condition is commonly recognized at birth. The skin overlying the affected joints appears smooth, lacking the normal



Fig. 1. Complete absence of the distal interphalangeal joint in a case of symphalangism of the fourth finger. Similar findings were present in the patient's mother and her 2 daughters. The toes were also affected.

folds produced by flexion which is absent. Depending upon which fingers are involved, symphalangism may be of little clinical significance or cause severe inability to grasp or perform movements where flexion is involved. Most commonly, the unaffected joints compensate for the immobility of those affected by symphalangism.

#### ROENTGENOGRAPHIC FINDINGS

Symphalangism cannot be detected on roentgenograms during infancy. No evidence of synostosis can be seen as the parts affected have not yet ossified. When ossification occurs, the affected joint will show a faster rate of epiphyseal fusion than the

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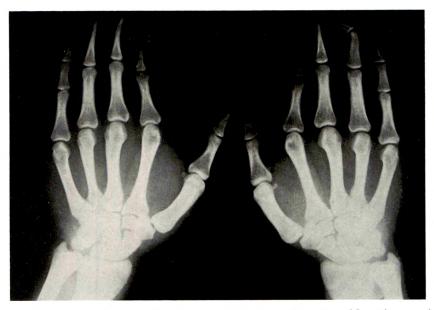


Fig. 2. Bilateral symphalangism occurring in a young Italian male patient. Note the complete loss of landmarks at the level of the absent joints.

rest of the interphalangeal joints. The joint space then becomes narrowed until complete bony fusion occurs. Various degrees of fusion may be present and thus there may be marked narrowing of one joint, or complete absence of the joint space (Fig. 1). The segment appears as a single longer



Fig. 3. No abnormalities were suspected in this young Negro male who injured his right foot. Symphalangism was detected at the third, fourth and fifth toes. A faint, dense line of demarcation is noted at the site of the absent fourth distal interphalangeal joint.

phalanx with a common bone marrow cavity and continuity of the trabecular pattern. This variety occurs less frequently (Fig. 2). More often one can see the lost joint space as a thin dense line which should not be mistaken for a nonossified epiphyseal line which is found frequently in these cases (Fig. 3). This is due to the fact that the synostosis precedes the normal fusion of the epiphysis with the phalangeal shaft. In other instances the site of the symphalangia can be identified by mild notching occurring at both lateral and medial aspects of the fused joint with no evidence of demarcation between the two phalanges (this is seen in the common symphalangism of the fifth toe) (Fig. 4, A and B).

#### DIFFERENTIAL DIAGNOSIS

Acquired ankylosis of the interphalangeal joints can usually be differentiated from symphalangism roentgenographically as well as by the clinical history. On roentgenograms, the joint in the acquired condition may be completely obliterated but an irregular articular surface can be seen with severe roughening or destruction. It is found after arthritic or inflammatory





Fig. 4. (A and B) Roentgenograms of the hands and feet of a 17 year old white male patient who entered the hospital with renal disease. Symphalangism was noted to be present in the fifth fingers. Observe the mild notching occurring at the site of the nonsegmented joints. Similar anomalies can be noted in the toes. The right middle finger was partially amputated in an accident. *Insert.* Photograph of the fifth digit showing the lack of normal flexion folds and smooth skin overlying the affected joint.

changes of the interphalangeal joints (Fig 5, A and B). The segment involved is usually ankylosed in flexion and there may be surrounding soft tissue swelling. The normal skin folds are present and clinical correlation is obtained; a previous history of one or several diseased joints exists.

Symphalangism is always present at birth and occurs in the proximal interphalangeal joints as a rule. It also involves several fingers but is seldom generalized; the affected segments are always in extension rather than flexion and the smooth aplasia or hypoplasia of the joint is noted along with the roentgen signs described. The skin folds are absent.

#### SUMMARY

A brief description of the rare anomaly called "symphalangism" is given. It consists of a congenital, hereditary lack of formation of the interphalangeal articulation with absence of the joint space and fusion of the adjoining phalanges in hands or feet. Stiffness of the affected joint is noted clinically with absence of the normal skin folds and a hindrance of normal movements. This condition is frequently associated with other congenital anomalies. Typical roentgen signs are present in these cases and should be differentiated from those of acquired ankylosis of the inter-



Fig. 5. (A and B) This 23 year old patient was examined for a suspected fracture of the middle finger. Pseudosymphalangism was noted in the index finger. This represents acquired, postinflammatory ankylosis and should be differentiated from true symphalangism.

phalangeal joints. The anomaly is frequently seen in the fifth toes of otherwise normal persons.

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## CARPAL FUSIONS

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THE incidence of some carpal anomalies differs among racial groups probably because of the genetically determined nature of some of these carpal variations. This paper is concerned with various aspects of the lunato-triquetral, capitate-hamate and pisiform-hamate joined bones as seen in Nigeria.

The material discussed was obtained in three fashions. In order to secure relative incidence figures, wrist roentgenograms of adults belonging to particular ethnic groups were made in their locale. The series is not as large as one might desire owing to various factors such as distance, cost, etc., but is adequate to provide an indication of the frequency of these anomalies. In addition, cases with carpal anomalies of all age groups that have been seen in the Department of Radiology, University College Hospital, Ibadan, formed the basis for other aspects of this study. This was supplemented by inspection of the skeletal collection housed in the Department of Anatomy of University College, Ibadan.

#### LUNATO-TRIQUETRAL FUSION

The first to mention this anomaly was Sandifort<sup>23</sup> in 1779 but he provided no descriptive details. It is significant that the second recorded instance of this bone was in the wrist of a skeleton of a Negro.<sup>28</sup> Since that date it has become evident that some sections of the Negro race have a high incidence of the condition. However, in most races an occasional case may be seen, though I have only been able to find records of its presence in Europeans,<sup>2,5,13</sup> Americans,<sup>3</sup> Israelis,<sup>11</sup> Japanese,<sup>29</sup> and Australian aborigines<sup>26</sup> and numerous examples in Negroes.

Table I shows the incidence of the joined bones in several series arranged in ascend-

ing order of frequency. It is striking that most Caucasian groups show a figure around 0.1 per cent but that all the Negro figures quoted are over 10 times this figure, reaching as high as 9.5 per cent in Hausa females. On the map of Africa (Fig. 1) the frequency distribution is plotted schematically. It is evident that there are enormous gaps in our knowledge of this aspect. The maximal incidence is found in West Africa, particularly in Nigeria, and the figure diminishes as one crosses the continent so that at Nairobi in Kenya and Dar es Salaam in Tanganyika the condition is virtually unseen,16,31 although MacKay14 found some cases among the Wadigo tribe. Farther south in Central Africa, Palmer<sup>21</sup> and his colleagues in Bulawayo at a large African hospital, have not encountered this carpal anomaly although they have noted other types. Minnaar<sup>17</sup> reported 12 cases from Johannesburg but did not give the actual incidence which I do not believe to be high. Moreover the population coming to this hospital is of very mixed ethnic origin owing to the extensive employment in the gold fields of migrant labor often derived from lands many thousands of miles from the Republic of South Africa. These carpal anomalies are seen from time to time in Sudanese<sup>10,25</sup> but the frequency does not seem to be high in Khartoum.

#### NATURE OF THE FUSION

The term fusion is, strictly speaking, in correct as the basic fault is considered to be a failure of separation. During development the cartilaginous anlage of bones forms around the fifth intrauterine week. At the site of future joint cavities, a jelly-like substance appears proximally and the cartilage becomes cleft into separate structures that will later form the individual bones com-

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Table I
INCIDENCE OF OS LUNATO-TRIQUETRUM

Incidence (per cent)	Ethnic Group	Size of Series	Author
0.05	French	8,000	Cabon, 5 1950
0.07	Japanese	1,400	Wetherington,29 1961
0.08	German	5,000	Arens,2 1950
0.13	American (Detroit)	743	O'Rahilly, <sup>19</sup> 1953
0.14	American (Tennessee) No indication of race	1,452	Bogart, <sup>3</sup> 1932
0.14	Scandinavian	2,100	Lönnerblad, 13 1935
1.87	Wadigo (East Africa)	749	MacKay,14 1952
		(under age of seven	)
3.8	Kampala, Uganda	596	Composite group: Dean and Jones, <sup>9</sup> 1959, and Davies, <sup>8</sup> 1959
3.8	Senegalese	I,000	Pellegrino and Joly, <sup>22</sup> 1959
5.9	Ghanian	680	Smitham, <sup>27</sup> 1948
7.4	Birom (Nigeria)	400	Cockshott
6.1	Ibo (Nigeria)	226	Cockshott
8.3	Yoruba Males (Nigeria)		C 1.1
7.3	Yoruba Females (Nigeria)	923	Cockshott
8.3	Hausa Males (Nigeria)		Calalan
9.5	Hausa Females (Nigeria)	500	Cockshott

prising the articulation. O'Rahilly<sup>20</sup> has suggested that it is failure of the formation of these articular interzones that results in persistent continuity of cartilage which later becomes bone. In support of his contention he mentions having observed lun-

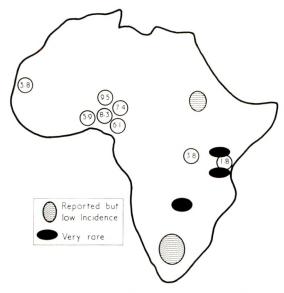


Fig. 1. Map of Africa showing percentage frequency of os lunato-triquetrum.

ato-triquetral "fusion" in a 156 mm. C. R. embryo. The present writer has dissected the wrists of many stillborn children in Ibadan. A section through an os lunato-triquetrum of a stillborn child reveals that the elements are joined together in the cartilage state (Fig. 2, A and B). This confirms that the process occurs in cartilage and that when one speaks of roentgenographic fusion of these bones one implies that the process is rather a unification or joining of ossific nuclei which does not differ from fusion of ossific centers occurring elsewhere in the body.

The theory that a bony fusion is due to assimilation of an accessory bone between two bones is no longer seriously held.

#### MATURITY OF THE FUSION

In the author's experience, the age at which the ossific centers join shows very wide variation with a range between under 6 years to over 15 years (Fig.3, A–F). This is also reflected in the few reports available in the literature. Silverman,<sup>24</sup> and Dean and Jones<sup>9</sup> were fortunate enough to be able to follow the progress of fusion in individuals

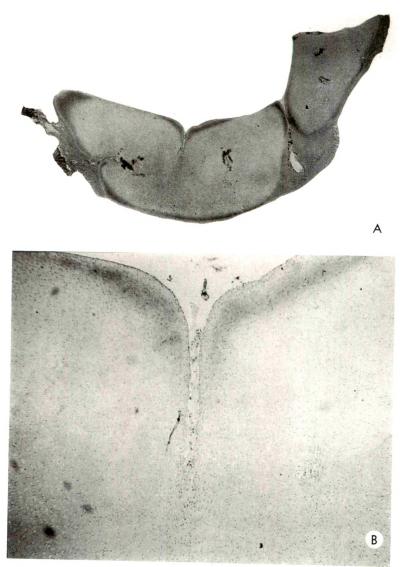


Fig. 2. Sections of fused os lunato-triquetrum in cartilage from wrist of a stillborn fetus. A proximal sulcus is present. (A) Low-power photomicrograph. On the right side the lunato-scaphoid joint can be seen. (B) High power photomicrograph showing the sulcus above and the fusion below.

being studied at intervals during longitudinal studies carried out for other reasons. Completion of fusion was noted at the ages of 8 years; 11 years, 2 months; 11 years, 3 months; 11 years, 7 months; 15 and 17 years. (This last individual had a bone age of 15.) Wetherington<sup>29</sup> noted fusion in a Japanese male aged 8½ years and Caffey<sup>6</sup> described the completion of the process in a female aged 7. Pellegrino and Joly<sup>22</sup> saw a case of fusion in a Senegalese aged 10.

The process of fusion is not always the same and three patterns can be demonstrated. In the most usual, when fusion is imminent, the proximal part of the elongated triquetral portion appears to overlap the lunate and then joins proximally (Fig. 3, A and B). As a result, a gap is left distally which may become obliterated as fusion proceeds so that it is no longer evident (Fig. 3, C and D; and 6, A and B). Sometimes the distal notch may persist per-

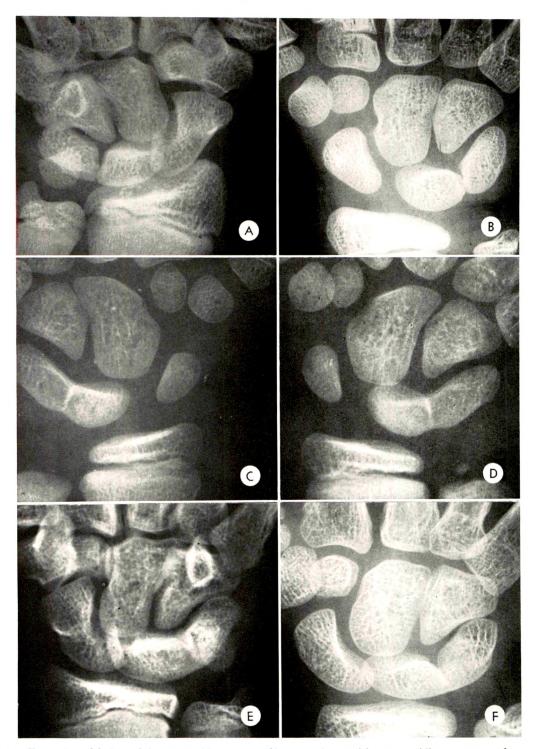


Fig. 3. Examples of fusion of the two ossific centers of lunato-triquetral bones at different stages of maturation and various chronologic ages. (A) Five year old female; (B) 8 year old female; (C and D) 6 year old female with sickle cell anaemia; (E) 13 year old female with complete fusion and well marked distal notch; and (F) 10 year old male with incomplete fusion.

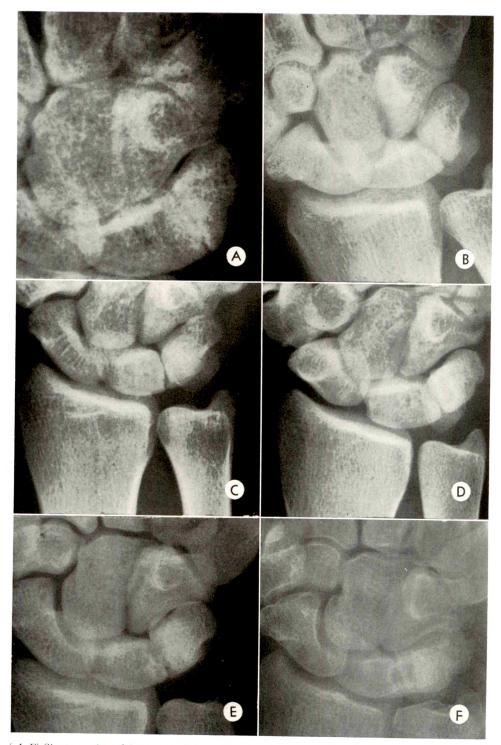


Fig. 4. (A-F) Six examples of fractures of the os lunato-triquetrum. A is the most recent and shows a mere fissure, while in F established nonunion with cyst formation is evident.

manently so that the bone is grooved distally. Five examples of this notch were encountered in 14 skeletons of adults with os lunato-triquetrum, found in the collection of the Department of Anatomy of University College, Ibadan, and also in 2 stillborn children.

A second type of fusion is described and illustrated by Dean and Jones. The union commences in the middle part of the opposed surfaces and as the junction matures a small proximal groove may persist. This groove has been illustrated by Minnaar and one such case was seen in the Ibadan skeletal collection.

The last form of fusion has as its stigma a temporary transverse sclerotic band of bone marking the point of union unaccompanied by any notching (Fig. 3, *C* and *D*). This type has been illustrated by Silverman<sup>24</sup> and Caffey.<sup>6</sup>

The triquetral portion of the joined bones is longer than normal. This is best seen in unilateral cases where a comparison of the two sides can be made, but this relative lengthening is usually obvious as can be seen on the roentgenographic reproductions in this article. A further change that is more difficult to appreciate has been described by Dean and Jones<sup>9</sup> in their excellent and careful study. They noted rotation of the bones about an axis more or less parallel to the radio-ulnar joint. This feature is not as constant as the triquetral lengthening.

#### ASSOCIATED ANOMALIES

In the Nigerian cases found in the survey, the bone anomaly, when present, was bilateral in 61.5 per cent of individuals; on the right side in 17.4 per cent and on the left in 21.1 per cent. These figures refute the thesis of both Minnaar<sup>17</sup> and Smitham,<sup>27</sup> who have claimed that unilateral left sided fusions occur only in Caucasians.

The most frequent associated anomaly was capitate-hamate fusion. The presence of both of these anomalies was seen in 5 cases in this survey (Fig. 5, A, E and F). It has also been recorded by Smitham<sup>27</sup> and

Minnaar.<sup>17</sup> One case was found with bilateral lunato-triquetral fusion and bilateral hamate-pisiform union. The coexistence of os lunato-triquetrum and Madelung's deformity is probably coincidental.<sup>1</sup> Most authors state that a wrist with fused bones shows normal function. This hypothesis was put to the test by Dean and Jones<sup>9</sup> who observed the range of movement in wrists of persons with this anomaly. They felt that radial deviation was greater in those with fused bones but otherwise no differences were detected.

#### FRACTURE OF FUSED BONE

Whether or not the presence of fusions confers an advantage in range of movement or not, the individual with the single bone is exposed to the risk of fracture. Six cases of fractures are shown in Figure 4, A-F. Some are recent but others show established nonunion with sclerosis, cyst formation and pseudoarthrosis. It is of interest to note that the fracture line in these instances passes close to the position of the expected joint. The persistence of the distal proximal grooves already described may be an important etiologic factor. It is possible that Figure 4C represents a "forme fruste" of fusion but the existence of this condition is hard to accept on embryologic grounds. Fracture of an os lunato-triquetrum has previously been described by McGoey<sup>15</sup> and Smitham.27

#### CAPITATE-HAMATE FUSION

This fusion in the distal row of the carpus is rare and there are few reports available. Its existence is not mentioned in the standard radiologic textbooks. The first report appears to be by Bogart<sup>3</sup> who described several cases in 1932. Hudson<sup>12</sup> reported the anomaly in 1943 and White<sup>30</sup> in 1944. There is no doubt that this abnormality is far more frequent in members of the Negro race (Table II).

As in the os lunato-triquetrum, there is often a distal sulcus at the point where there normally would have been a joint space (Fig. 5, A, B and D; and 7B), but this

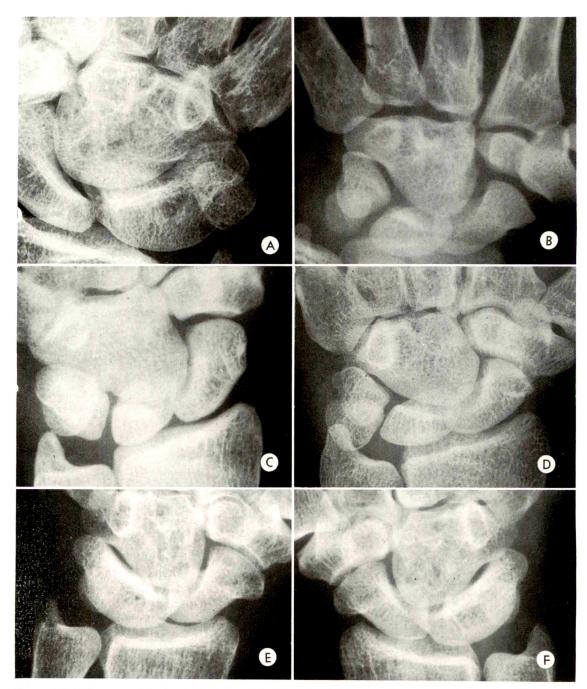


Fig. 5. (A-F) Six examples of os capitate-hamate fusion. In A, E and F, there is also lunato-triquetral fusion. In A, B and D a distal notch close to the cleft between the bases of the third and fourth metacarpals is present. E and F are from the same individual.

Table II
INCIDENCE OF CAPITATE-HAMATE FUSION

Incidence (per cent)	Ethnic Group	Size of Series	Author
0.14	Wadigo (East Africa)	1,360	MacKay,14 1952
0.29	American (Tennessee)	1,452	Bogart, 3 1932
0.25	American (Detroit)	74.3	O'Rahilly,19 1953
0	Birom (Nigeria)	400	Cockshott
0.4	Hausa (Nigeria)	500	Cockshott
0.5	Yoruba (Nigeria)	923	Cockshott
0.8	Ibo (Nigeria)	226	Cockshott
0.73	Ghana	680	Smitham,27 1948

is by no means invariable (Fig. 5, C, E and F; and 7A). The fusion is more frequently unilateral than bilateral.

#### AGE AT FUSION

As the ossific centers for the two individual bones are the first to appear and may be evident at birth, it is not surprising that union of bony centers occurs early. Previously we have described bilateral fusion at  $1\frac{1}{2}$  years of age in a child with Kwashiokor<sup>7</sup> and have observed well fused bones at 2 and 3 years of age. Fusion in females aged 3 and 4 is demonstrated in Figure 6,  $\mathcal{A}$  and  $\mathcal{B}$ . A female dwarf, brought to

the hospital because of failure to thrive, was allegedly 2 years old at the time of the first examination and showed early fusion on one side and a single ossific center in the other wrist (Fig. 7, A and B). Thirteen months later fused bones were present on both sides but the maturation had proceeded in an anomalous manner in the wrist (Fig. 7, C and D) and elsewhere. Her fontanelles were still open. Normally fusion is established and obvious before the age of 2.

The genetics of the condition have not been studied. The author has seen examples in identical twins. White<sup>30</sup> reports normal wrists in the parents of his case.

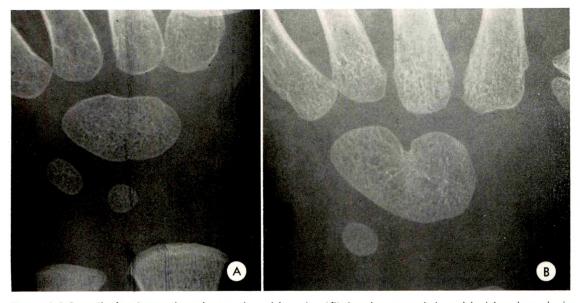


Fig. 6. (A) Soundly fused os capitate-hamate in a girl aged 3. (B) Another example in a girl with a chronologic age of 4. This Figure shows an early stage of maturation of the bone without and with a notch.

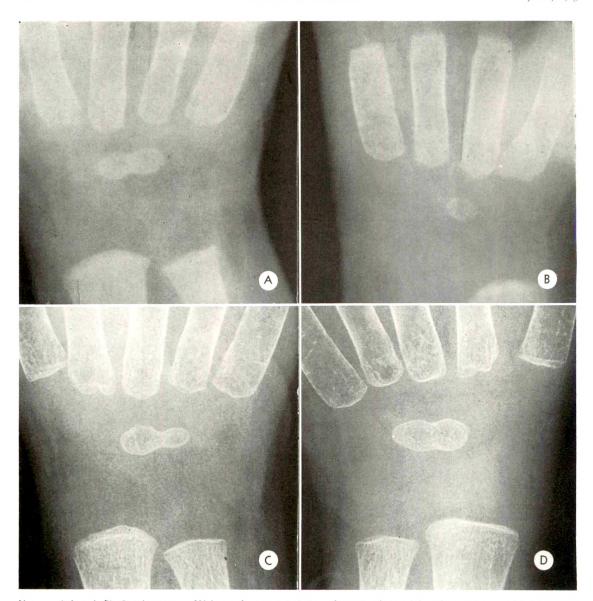


Fig. 7. (A and B) October 1057: Wrists of a retarded dwarf aged 2 but with a bone age considerably less Early fusion is seen on one side. (C and D) November 1058: The right wrist had shown hardly any maturation but on the left the fused bone had grown considerably. The exact cause of generalized delayed maturation in this child was not established.

Fracture of an os capitate-hamate has not been described.

#### PISIFORM-HAMATE FUSION

In 1959 the author recorded a bilateral anomaly in which there was bony continuity between the hook of the hamate and the pisiform bone. Since then, another such case has been seen in which bilateral os

lunato-triquetrum was also present. The first patient was a Yoruba (Fig. 8, A and B) and the second of the Birom tribe from the Jos plateau in Northern Nigeria (Fig. 9, A and B). A case was also seen by Dr. Bunning in the Anatomy Department at Ibadan.

This type of bony union has not been described previously. Bogart<sup>3</sup> mentions assimilation of a secondary pisiform with a

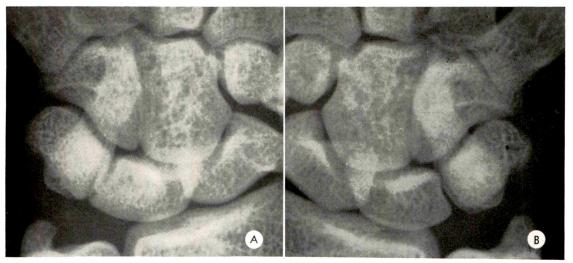


Fig. 8. (A and B) Bony bridge between hook of hamate and the pisiform in an adult Yoruba.

pisiform and pisiform triquetral fusion.

The nature of this anomaly must for the moment remain controversial. These cases are not pathologic ossification in the distal tendon of flexor carpi ulnaris; nor can they be considered due to the failure of formation of articular interzones during embryonic maturation. Perhaps this tongue-like extension of bone joining the hamate to the pisiform can be regarded as a metaplastic conversion of a ligamentous structure into bone.

#### DISCUSSION

It is apparent that some sections of the Negro race have a high frequency of certain carpal fusions. The genetics of these anomalies have not been studied as yet in any great detail. Family studies of individuals showing two types of fusions at the same time would be particularly illuminating in elucidating the method of transmission.

It is possible that the study of the relative incidence of these and other anomalies by roentgenography may prove useful to

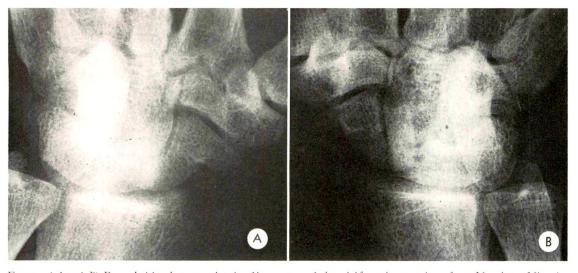


Fig. 9. (A and B) Bony bridge between hook of hamate and the pisiform in a patient from Northern Nigeria. In addition bilateral lunato-triquetral fusion is present. (Poor quality of the roentgenograms attributable to field conditions.)

anthropologists for the tracing of past population movements and ethnic relationships of tribes. Statistical evaluation of blood groups, *i.e.* abnormal hemoglobins, secretor status, glucose-6-dehydrogenase deficiency trait, etc., already provides genetic markers of varying value. Comparative statistical physical anthropology, biochemistry and linguistics may yet reveal a great deal of the prehistoric period of Africa. Already as a result of such studies a complete reorientation of views on the origin and movement of the so-called Bantu peoples has taken place.

It is time for roentgenography to be utilized as an ancillary method in physical anthropology. Rather than measuring and recording bone indices of skeletal material of uncertain ethnic origin, a systematic but limited roentgenographic investigation could provide objective data from a sample of known composition. By careful selection of the technique, there need be no ethical objection because of radiation exposure. The more parameters studied, the greater should be the precision.

#### SUMMARY

The incidence of lunato-triquetral, capitate-hamate and pisiform-hamate fusions is shown to be high in Negroes; in lunato-triquetral fusion the incidence may be nearly a hundred times greater than in Europeans. The morphology and development of these fusions are described. Associated anomalies and fractures of fused bones are also discussed.

It is suggested that roentgenographic studies should be more widely employed in physical anthropology.

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searching the Smith Skeletal Collection of the Department of Anatomy of University College, Ibadan, is greatly appreciated. My thanks are due to the Department of Medical Illustration, University College, Ibadan, and I am also grateful to the numerous radiographers who have assisted in these studies.

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## LATERAL COMPARISONS OF THE SKELETAL MATURITY OF THE HUMAN HAND AND WRIST\*

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INSPECTIONAL assessments of the skeletal maturity of the left hand-wrist area are being applied clinically with increasing frequency. Consequently, it is important that possible limitations to their usefulness be investigated fully. If the left hand-wrist area commonly matures skeletally at a rate that is different from the rate of maturation of the remainder of the skeleton, unmodified assessments of left handwrist skeletal age could not provide a reliable estimate of general skeletal maturity. In the absence of satisfactory roentgenographic standards of maturational status for all parts of the skeleton, it is impossible to determine directly the relative rates of maturation of all areas.

In the study of apparently normal children that is reported here, the skeletal maturity of the hand-wrist areas of the two sides has been compared. One would expect some lateral differences in skeletal maturity and, if these lateral differences were large, the usefulness of skeletal age assessments based on only one side could be seriously questioned.

### REVIEW OF LITERATURE

Indications that skeletal maturation in the hand-wrist area has a significance that is general for the skeleton are provided by its high positive correlations with percentage attainment of mature stature<sup>6</sup> and with the maturation of the reproductive system.<sup>28</sup> Studies of the number of ossification centers roentgenographically visible in different parts of individuals<sup>1,12</sup> indicate that, if the technique is simple enumeration of centers, study of the hand-wrist area is in-

adequate for assessment of the maturation of the entire skeleton. It has been shown, however, that the age of fusion of hand epiphyses with their shafts in individuals is correlated closely with the fusion of the proximal tibial epiphyses with their shafts in the same individuals. Despite the high positive correlation between the ages at which these fusions are first observed, the timing of the two events may be separated by as much as 2 years in some individuals.

High positive correlations have been reported between the skeletal maturity of the hand-wrist area and that of the foot,<sup>5</sup> of five other areas<sup>16</sup> and the average of six areas including the hand-wrist area.<sup>27</sup> These studies have been made using unpublished standards of skeletal maturation for areas other than that of the hand-wrist.

Wide variations in maturational status of individual bones within the hand-wrist areas of individuals would indicate that the average skeletal age of the bones within this area might be an unreliable guide to general skeletal maturity. Sawtell<sup>26</sup> reported that the rates of maturation of different bones within the area were similar. Hansman and Maresh<sup>15</sup> stated that they found occasional large variations in skeletal maturity between the carpals and the long bones and between individual digits. The variations in skeletal maturity status within the hand-wrist areas of individuals reported by Dreizen et al.7 were larger for those bones of which the age at onset of ossification is markedly variable. 9,23 Data have not been reported which would allow one to determine whether the variations are sufficiently large or common to make

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hand-wrist skeletal age assessments unreliable.

The data reported in the literature relative to the lateral symmetry of hand-wrist maturation will be discussed under several headings.

## I. NUMBER OF BONES OSSIFIED

Although it is usual for the same number of bones to be ossified in the hand-wrist areas of the two sides, small lateral differences in the number may be present during fetal life, 21 at birth 19 and in children. 9,10,26,30 Sawtell, 26 referring to carpal centers, stated that "in the rare cases in which first appearance is asymmetrical, the second center usually commences ossification within the next three months."

## 2. MEAN SKELETAL AGE

Some workers, 4.22,29 before the inspectional methods of skeletal age assessment had been published, compared bilateral roentgenograms of the hand-wrist areas of individuals and concluded that the differences in ossification between the two sides were very small. Long and Caldwell<sup>17</sup> and Allen,² however, reported that there were marked lateral differences.

Dreizen et al.<sup>7</sup> reported lateral differences of skeletal age exceeding 6 months in 1.5 per cent of 450 children. They concluded that the "divergencies in the over-all skeletal maturation of the two hands are so minor as to be negligible in the evaluation of skeletal status." Greulich and Pyle<sup>14</sup> reported an analysis of bilateral hand-wrist skeletal age assessments of 435 children, in 13 of whom there was a lateral difference in average skeletal age. The average skeletal ages of the two sides were identical in the remainder.<sup>24</sup>

Several workers<sup>3,9,14</sup> have recorded evidence that there is no statistically significant tendency for a particular side of the body to be advanced in skeletal maturation. Menees and Holly,<sup>19</sup> Flecker<sup>10</sup> and Dreizen *et al.*<sup>7</sup> reported that in a majority of individuals the right side was more ad-

vanced skeletally than the left. Torgersen<sup>30</sup> stated, however, that if there was a lateral asymmetry in this regard, usually the left hand-wrist area had more roentgenologically opaque ossific centers than the right. In his data, the differences between the two sides were statistically significant although "too small to be a source of error in the determination of developmental status." Menees and Holly19 report data which indicate that the side on which ossification was more advanced at birth later became the side of dominant function. Elgenmark,9 however, found no evidence in his data that the side of greater function matured skeletally at a more rapid rate than the other.

## 3. SKELETAL AGE OF INDIVIDUAL BONES

Dreizen *et al.*<sup>7</sup> reported differences that were statistically significant at the 5 per cent level between the individual bones of the hand-wrist area in the frequency of lateral asymmetry of maturational status. There is some evidence that such lateral asymmetry is more common in the carpal bones than in the long bones of the hand-wrist area.<sup>3,7,14</sup> Elgenmark<sup>9</sup> stated that "bilateral differences in appearance of centres of ossification tend to be localized in the epiphyses of the phalanges" but his published data do not appear to warrant this conclusion.

#### MATERIAL

As part of a multi-discipline serial study of the physical growth of normal white Australian children, <sup>25</sup> the hand-wrist areas of both sides were roentgenographed using the technique described by Greulich and Pyle. <sup>14</sup> Bilateral roentgenograms of 119 children (61 boys, 58 girls), ranging in chronological age from 3 years 5 months to 4 years 7 months, were assessed by the present author using the Greulich-Pyle standards. <sup>14</sup>

Throughout this report the term "hand-wrist area" is used to include the hand, the carpus and the distal epiphyseal areas of the radius and the ulna.

 $T_{ABLE\ I}$  lateral comparisons of the number of bones ossified (boys/girls)

	$P_{\scriptscriptstyle 1}$	$\mathrm{P}_2$	$Z_1 - Z_2$	
			s.d. $(Z_1 - Z_2)$	
Carpal bones Long bones All bones	0.131/0.321 0.033/0.036 0.164/0.321	0.115/0.196 0.0/0.0 1.115/0.196	0.26/I.34 I.3/I.3 0.73/I.3I	

 $P_1$ = proportion of individuals in whom more bones were ossified on the left side than the right side;  $P_2$ = proportion of individuals in whom more bones were ossified on the right side than the left side:

$$\frac{Z_1 - Z_2}{\text{s.d. } (Z_1 - Z_2)} = \text{unit normal variant.}$$

#### FINDINGS

## I. NUMBER OF BONES OSSIFIED

In 46 of the 61 boys and 27 of the 58 girls, equal numbers of bones were ossified in the hand-wrist areas of the two sides but in 3 children not all the ossified bones were corresponding ones. Lateral differences in the number of bones ossified were more common among the carpal bones than among the long bones of the hand-wrist area. In both sexes, there was a tendency for the number of bones ossified on the left side to be greater than the number on the

right. This tendency is reflected in the differences between the values of  $P_1$  and  $P_2$  shown in Table 1.

P<sub>1</sub> and P<sub>2</sub> are random variables with variances approximately

$$P_1 \, \frac{(\mathtt{I} - P_1)}{\mathsf{n}} \quad \text{and} \quad P_2 \, \frac{(\mathtt{I} - P_2)}{\mathsf{n}}$$

respectively and co-variance

$$-\frac{\mathrm{P_1P_2}}{\mathrm{n}} \cdot$$

To test the significance of the differences

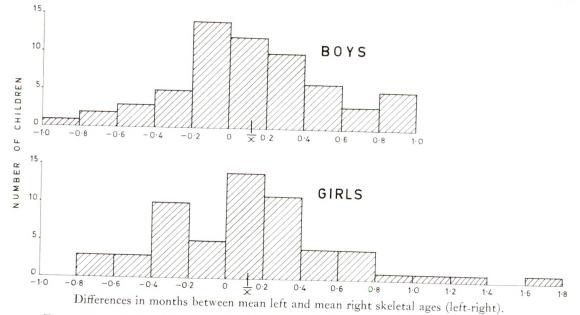


Fig. 1. Histograms of the lateral differences of mean skeletal age in boys and girls;  $\bar{x} =$  mean difference.

between  $P_1$  and  $P_2$ , it was considered advantageous to transform  $P_1$  and  $P_2$  to other variables  $Z_1 = 2$  arc sin  $\sqrt{P_1}$  and  $Z_2 = 2$  arc sin  $\sqrt{P_2}$  because the variances of  $Z_1$  and  $Z_2$  are equal to 1/n and are independent of the values  $P_1$  and  $P_2$ . The variance of the difference between  $Z_1$  and  $Z_2$  is given in the formula

$$\frac{2}{n}\bigg[\mathbf{1}\!+\!\sqrt{\frac{P_1P_2}{(\mathbf{1}\!-\!P_1)(\mathbf{1}\!-\!P_2)}}\bigg]$$

in which the term

$$\sqrt{\frac{P_1P_2}{(1-P_1)(1-P_2)}}$$

is dependent on  $P_1$  and  $P_2$ . If  $P_1$  and  $P_2$  are small, as in the data being considered, this term does not have much influence on the size of var  $(Z_1-Z_2)$ .

The values of

$$\frac{Z_1 - Z_2}{\text{s.d. } (Z_1 - Z_2)}$$

demonstrate that, in both sexes, differences between the number of individuals in whom more bones were ossified in the left handwrist area and the number in whom more bones were ossified in the right hand-wrist area were not statistically significant.

#### 2. MEAN SKELETAL AGE

Histograms were drawn to show the distribution of the lateral differences between the mean skeletal ages of the hand-wrist areas (Fig. 1). The largest lateral difference between the mean skeletal ages was 1.76

TABLE II

LATERAL DIFFERENCES IN MEAN SKELETAL
AGE IN MONTHS

Positive values indicate that the
left side was the more mature

	Mean	s.d. of Distribution	"t"
Boys	+0.109	0.411	2.07* (60 d.f.)
Girls	+0.121	0.475	1.94 (57 d.f.)

<sup>\*</sup> Significant at the 5% level.

months. This occurred in a girl; among the boys the largest lateral difference was 1.0 month. It can be seen (Table II and Fig. I) that the mean skeletal ages tend to be larger on the left side than the right side in both sexes. The differences, although small, are real. This is indicated by the value for "t." This is just large enough to be significant at the 5 per cent level in boys and is slightly lower than this value in girls.

These mean skeletal ages were derived from the skeletal ages of individual bones. If wide variations occurred commonly between the skeletal ages of individual bones and the mean skeletal age on the same sides of the same individuals, one might expect the skeletal ages of individual bones in other areas to vary widely and commonly from the mean skeletal age of the handwrist area. The presence of variations of this nature would cast doubt on the reliability of hand-wrist skeletal age as an index of general skeletal maturity.

The difference between the skeletal age of each bone and the mean skeletal age on that side was calculated for each child. The means of the differences between the skeletal ages of individual bones and the mean skeletal ages of the hand-wrist areas on the same sides of the same individuals were calculated for all the children on the left side and for 10 boys and 10 girls on the right side. These data demonstrated that the patterns of differences from the respective mean skeletal ages were similar on the two sides. Consequently, the subsequent calculations relative to this aspect of the investigation were based on data obtained from the left side only.

The correlation coefficients between the deviations for some pairs of bones were calculated using the entire sample of children. The values of all these coefficients were small positive ones. Graphs (Fig. 2 and 3) were drawn of the mean differences for individual bones together with their ranges (±1.5 s.e.). Data relating to the ulna were omitted from these graphs and from Tables III and IV because few were available. In many children, the skeletal

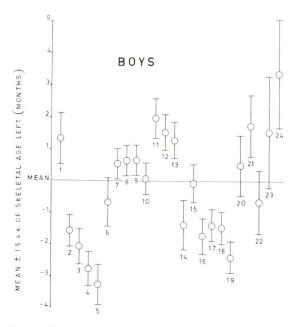


Fig. 2. The variation of the skeletal ages of individual bones from the mean skeletal ages on the same sides of the same boys. Each vertical line represents the mean  $(\circ) \pm 1.5$  s.e. The numbers indicate bones as follows:

1 - 5	Metacarpals	$I_{-}V$
6-10	Proximal Phalanges	I-V
11-14	Middle Phalanges	H-V
15-19	Distal Phalanges	$I_{-}V$
20	Radius	
2 I	Capitate	
22	Hamate	
23	Triquetral	
24	Lunate	

age of the ulna was not recorded because it is difficult to assign an accurate maturity level to this bone within the age range being considered. Data relating to the scaphoid, trapezium and trapezoid were omitted also because these bones had ossified in only a few children and these children were accelerated markedly in skeletal maturation. If the intervals from +1.5 s.e. to -1.5 s.e. for two bones do not overlap in these figures (Fig. 2 and 3), the difference between the two respective bones in the characteristic being considered is significant at the 5 per cent level. Thus one can consider, for example, the first proximal phalanx in the group of boys (Fig. 2). The tendency of the skeletal age of this bone to

vary from the mean skeletal age on the same side is correlated to a statistically significant extent with the corresponding tendencies of eleven other bones in the hand-wrist area. Similar conclusions would be drawn from a consideration of the correlations between other bones of this area. These graphs (Fig. 2 and 3) indicate that the skeletal age of some bones varies from the mean skeletal age on the same side in a particular direction. This variation was much more marked than the tendency towards a lateral difference between the mean skeletal ages (Fig. 1). Definitely in boys and doubtfully in girls, the individual rays of the hand tend to be less mature skeletally as one considers rays progressively closer to the ulnar side of the handwrist area.

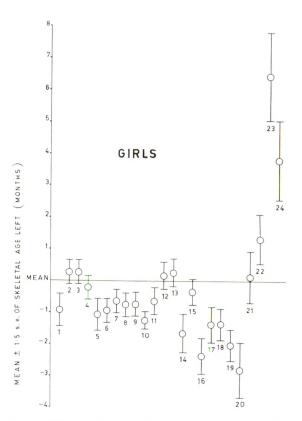


Fig. 3. The variation of the skeletal ages of individual bones from the mean skeletal ages on the same sides of the same girls. Each vertical line represents the mean (o) ± 1.5 s.e. The numbers correspond to bones in the same way as in Figure 2.

#### 3. SKELETAL AGE OF INDIVIDUAL BONES

Examination of the records showed that there had been a marked tendency to record the skeletal ages of individual bones in even numbers of months more commonly than in odd numbers. As a result, the lateral differences between the skeletal ages of individual bones are more commonly even numbers of months than odd numbers.

The mean lateral differences between the skeletal ages of individual bones have been recorded in Table III. The left side was more advanced skeletally than the right for the majority of bones in both sexes. The pattern of the differences was similar in both sexes. Six of the boys and 7 of the girls were left-handed and an examination of the data indicated that there was no tendency for the rate of maturation to be influenced by greater function on one side than the other.

The statistical significance of this tendency of individual bones to have lateral differences in skeletal age was tested by calculating the value of

$$\frac{Z_1 - Z_2}{\text{s.d.} (Z_1 - Z_2)}$$

for each bone (Table IV). The lateral differences were significant for some bones and this occurred for more bones in boys than in girls. This reflects the fact that the lateral differences in skeletal age of individual bones tended to be larger in the boys studied than in the girls (Table III).

#### CONCLUSION

The lateral asymmetry of skeletal maturation that was observed during the present study was not sufficient to invalidate conclusions regarding general skeletal maturity based on observations of one handwrist area. This finding would be expected from a consideration of earlier reports of high positive correlations between the skeletal maturity of one hand-wrist area and the maturity of other parts of the skeleton<sup>5,16</sup> and of the reproductive system.<sup>28</sup>

Table III
MEAN LATERAL DIFFERENCES IN MONTHS

	Boys	Girls
Radius	+0.393	-0.228
Capitate	+0.441	+0.172
Hamate	+0.295	+0.034
Triquetral	+0.326	+0.039
Lunate	+0.278	+0.61
Metacarpal I	+0.18	+0.052
Metacarpal II	+0.246	+0.155
Metacarpal III	+0.279	+0.155
Metacarpal IV	+0.213	+0.328
Metacarpal V	+0.148	+0.052
Proximal Phalanx I	+0.197	+0.218
Proximal Phalanx II	+0.131	+0.179
Proximal Phalanx III	+0.033	+0.232
Proximal Phalanx IV	+0.229	+0.107
Proximal Phalanx V	+0.049	0.0
Middle Phalanx II	-0.049	-0.121
Middle Phalanx III	-0.016	-0.086
Middle Phalanx IV	-0.197	-0.138
Middle Phalanx V	+0.312	0.0
Distal Phalanx I	-0.069	+0.593
Distal Phalanx II	-0.098	0.0
Distal Phalanx III	-0.082	+0.121
Distal Phalanx IV	-0.049	+0.052
Distal Phalanx V	-0.18	+0.018

<sup>+</sup> indicates that the left side was more advanced skeletally; -indicates that the right side was more advanced skeletally.

Large lateral differences in mean skeletal age, as noted occasionally by Dreizen et al.,7 were not observed during this investigation. In this respect, the present findings are in agreement with those of Greulich and Pyle.14 The largest lateral difference noted during the present investigation was 1.76 months. Whether a difference of this magnitude is clinically significant is dependent, in part, upon the reproducibility of skeletal age assessments. Variable errors of 3 months,20 2.95 months18 and 0.8 months<sup>16</sup> have been reported for repeated assessments by the same observers. An analysis of repeated assessments, made during the course of the present investigation, shows a variable error of 1.1 months. A lateral difference in mean skeletal age of

Table IV

LATERAL DIFFERENCES IN THE SKELETAL AGE OF INDIVIDUAL BONES

	Boys			Girls
	No.	$Z_1 - Z_2$	No.	$\frac{Z_1 - Z_2}{\text{s.d. } (Z_1 - Z_2)}$
		s.d. $(Z_1 - Z_2)$		
Radius	61	+1.66	57	-0.17
Capitate	59	+3.04**	58	+0.79
Hamate	61	+2.08*	58	0.0
Triquetral	49	+1.53	51	0.0
Lunate	36	+0.19	4 I	+1.6
Metacarpal I	61	+1.84	58	0.0
Metacarpal II	61	+2.03*	58	+1.16
Metacarpal III	61	+2.14*	58	+0.43
Metacarpal IV	61	+2.68**	58	+1.55
Metacarpal V	61	+1.22	58	+0.43
Proximal Phalanx I	61	+0.93	55	+0.47
Proximal Phalanx II	61	+2.26	56	+2.5*
Proximal Phalanx III	61	+0.7	56	+2.09*
Proximal Phalanx IV	61	+3.1**	56	+1.29
Proximal Phalanx V	61	0.0	56	-0.33
Middle Phalanx II	61	0.0	58	-1.3
Middle Phalanx III	61	+3.79**	58	-0.28
Middle Phalanx IV	61	-I.42	58	-1.02
Middle Phalanx V	61	+1.74	54	0.0
Distal Phalanx I	58	-0.22	54	+2.34*
Distal Phalanx II	61	-0.92	58	0.0
Distal Phalanx III	61	-0.71	58	+1.08
Distal Phalanx IV	61	-0.71	58	+0.26
Distal Phalanx V	61	-I.87	57	-0.26

 $\frac{Z_1 - Z_2}{\text{s.d. } (Z_1 - Z_2)} = \text{unit normal variant};$ 

+indicates that the left side was more advanced skeletally; -indicates that the right side was more advanced skeletally; \*significant at the 5% level; \*\* significant at the 1% level.

the size recorded during this investigation has only a small influence on the calculation of estimated mature height. This can be demonstrated by calculating the estimated mature height of a girl with a present height of 120 cm. and a skeletal age of 6 years. Her estimated mature height would be  $166.6 \pm 3.7$  cm. (2 s.d.). If her skeletal age had been recorded as 6 years 1 month, her mature height would have been estimated as  $165.9 \pm 3.7$  cm. 6

The observation that, in a majority of the children studied, equal numbers of bones were ossified in the hand-wrist areas of the two sides confirms the opinions of earlier investigators. The lateral differences noted in the number of bones ossified were not statistically significant but they were greater for carpal bones than long bones and there was a tendency for more bones to be ossified on the left side than the right side. There was a corresponding tendency for mean skeletal age to be greater on the left side than the right and the lateral differences were real and were statistically significant in boys.

The tendency of individual bones to vary from the mean skeletal age on the same side of an individual was analyzed statistically. These tendencies were similar on both sides and in both sexes and some of the differences between bones in this regard were significant. Many bones had a marked tendency to vary in a particular direction, e.g., usually the second metacarpal in the group of boys was assessed lower than the mean. These variations could be due to the nature of the sample of children studied, to errors in the standards of maturational status or to errors made by the observer when using these standards. The variations of individual bones differ from those described by Dreizen et al.8 for children attending a nutrition clinic.

In the group of boys, the individual rays of the hand had a marked tendency to be less mature skeletally as one considered rays progressively closer to the ulnar side. This does not indicate necessarily that the ulnar side was less mature than the radial side in the boys studied. As noted above, it may be due to errors in the standards or in the technique of the observer.

It has been reported<sup>3,7,14</sup> that lateral differences in skeletal age are more common or more marked in the individual carpal bones than in the individual long bones of the hand-wrist area. In the present study, statistically significant lateral differences in skeletal age were present for more bones among boys than among the girls but there was no evidence that they were more common for carpal bones than long bones.

The present data indicate a tendency for the left side to be more mature than the right side. This is apparent in the number of bones ossified. It was noted also in the lateral differences of mean skeletal age which were small but real and were close to being statistically significant at the 5 per cent level in both sexes. The mean skeletal ages of individual bones were greater on the left side than the right for most bones in both boys and girls, and the lateral differences were statistically significant for some of these bones. This tendency for the left

side to be more advanced than the right is in conflict with most earlier reports except that of Torgersen.<sup>30</sup> There was no indication in the present investigation that the sides of greater function and more advanced maturation tended to correspond.

#### SUMMARY

- Bilateral hand-wrist roentgenograms of 119 children have been used to estimate lateral asymmetry of skeletal maturation.
- 2. In a majority of children, an equal number of bones was ossified on the two sides. In the remainder, there was a tendency for more bones to be ossified on the left side than the right side, but this difference was not statistically significant in either sex.
- 3. The largest lateral difference noted in mean skeletal age was 1.76 months. The more mature side was more often the left in both boys and girls. The lateral differences between the mean skeletal ages were real in both sexes and the difference was statistically significant in the boys.
- 4. Most individual bones tended to be more mature on the left side than the right side and for some bones the differences were statistically significant. The lateral differences tended to be smaller in the girls than in the boys.
- 5. Some bones showed a marked tendency to vary in a particular direction from the mean skeletal age on the same side.
- 6. It was concluded that, although real lateral differences in mean skeletal age occur, they are too small to limit seriously the usefulness of assessments based on one hand-wrist area.

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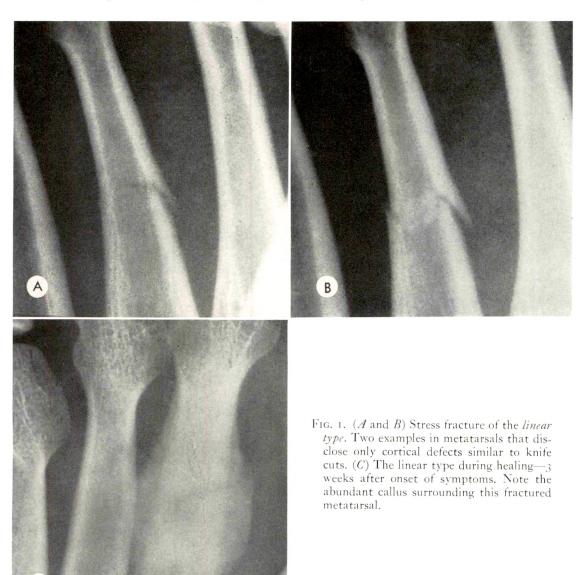
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## STRESS FRACTURES

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THE stress fracture, also named march fracture, fatigue fracture and boot fracture, is an entity which is being recognized more frequently throughout the gen-

eral population. In military basic training centers the stress fracture is a common orthopedic problem. It is the purpose of this article to present our observations concern-



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Fig. 2. Stress fracture of the *periosteal type*. Only a puff of periosteal reaction is present on the distal medial surface of this metatarsal.

ing this interesting lesion and propose a roentgenographic classification which we have found useful

#### ROENTGENOGRAPHIC CLASSIFICATION

The roentgenographic appearance of stress fractures is variable. It is our experience that stress fractures occur with equal frequency according to the following classification: (1) linear type; (2) periosteal type; (3) sclerotic type; (4) fragmentary type; and (5) mixed type.

The linear type (Fig. 1, A, B and C) simulates an oblique knife slice through the cortex of a long bone. Often all that is visible is a fine radiolucent cleft, and its detection is greatly facilitated by clinical evaluation. Healing produces abundant callus.

The periosteal type (Fig. 2) also occurs in the long bones and is even more difficult to detect. The fracture line is not visible. At the site of the lesion is a mere puff of periosteal reaction simulating a smudge on the roentgenogram. As healing ensues, this reaction becomes marked.

The sclerotic type (Fig. 3, A, B and C) occurs most commonly in the calcaneus but may be seen in the tubular bones. It presents as an area of sclerosis which varies in size and shape according to the extent and age of the process. The sclerosis disappears when healing is completed.

The fragmentary type (Fig. 4) is almost exclusively seen in the metatarsals. It has the appearance of a severely comminuted fracture associated with a crushing injury, but there is no history of this type of trauma.

When combinations of the other types are demonstrated on the original roentgenogram, we classify them as mixed types (Fig. 5, A, B and C). They are usually found in the tubular bones.

## DISCUSSION SYMPTOMS AND SIGNS

The first symptom of a stress fracture in by far the majority of cases is pain. The first sign is local tenderness. The pain, usually felt at the end of the day, is often described as a tiredness or soreness, and is frequently compared to a muscular or ligamentous ache. This discomfort is rarely severe enough to prompt complaint before the third day. The first steps in the morning or after a rest period are quite uncomfortable. This improves with light activity, but becomes more intense if weight bearing is prolonged. Swelling follows the onset of pain and local tenderness by several days. This is a diffuse, interstitial edema which decreases but does not completely disappear at night. An actual lump representing subperiosteal hematoma is easily felt in most stress fractures involving the tibia and metatarsals. This feature is not noted in fractures of the os calcis because only internal callus is formed. In metatarsal fractures, there may be slight increase in local heat and redness, suggesting an infection. Finally, these fractures are not infrequently multiple; i.e., bilateral os calcis;



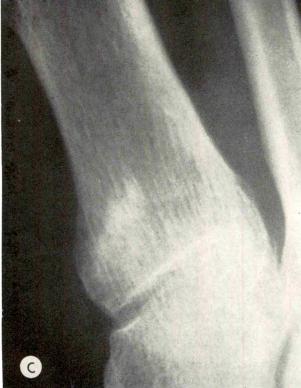


Fig. 3. Stress fracture of the *sclerotic type*. Three examples: (A) distal femur—the linea aspera terminates above the fracture; (B) calcaneus; (C) proximal first metatarsal.

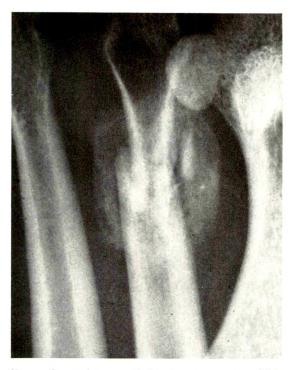


Fig. 4. Stress fracture of the *fragmentary type*. This metatarsal stress fracture already shows considerable healing and is about I week old.

second and fourth metatarsals of the same foot; os calcis and tibia. Many individuals recover from one stress fracture only to experience another upon resumption of training.

#### DIFFERENTIAL DIAGNOSIS

The differential diagnosis of stress fractures includes a variety of conditions. The linear type may be confused with a nutrient canal or mach effect. The periosteal and sclerotic types simulate inflammatory reaction to infection in the periosteum and cortex, respectively. The fragmentary type must be distinguished from a comminuted fracture of more violent trauma.

Probably the most important lesions to differentiate from are the malignant bone tumors. Early stress fractures may resemble Ewing's sarcoma, and the healing phases of these fractures may simulate the roentgen appearance of osteosarcoma.

Since most of these lesions occur in

young adults, age is not a helpful differentiating factor. A history of marching (or stress from a similar cause), acute onset of well localized symptoms, lack of other clinical findings and careful follow-up are essential for the correct diagnosis. Biopsy may occasionally be necessary in the most atypical cases.

#### TREATMENT

The management is designed to relieve the symptoms and allow the patient to continue with his duties. A check is made to ensure that footwear fits adequately. In addition, metatarsal stress fracture cases are given longitudinal arch supports. Patients with calcaneal involvement are treated with a ½ inch foam rubber heel lift. Light duties are prescribed, usually excluding marching over ½ mile, running and jumping. The foot fracture cases are advised that walking at a natural pace is much more comfortable than marching in cadence. Soaking the feet at night in warm Epsom salt solution is beneficial. Salicylates are usually sufficient to control pain.

We feel that *not* putting these patients at bed rest and *not* immobilizing them in casts are of the utmost importance. In our experience prolongation of the symptoms will uniformly result from bed rest and casts.

An explanation to the patient of the nature of the disease is essential to ensure full cooperation and to allay anxiety.

#### ETIOLOGY

The exact mechanism in stress fractures is unknown. There are few who would refute an unaccustomed amount of walking as the main precipitating factor. Another element that is certainly important is some peculiarity in the structure of the patient's bone that makes him susceptible to these fractures. We have been unable to correlate static foot conditions, obesity or handedness with the incidence of these fractures. Although we see few of these lesions after basic training, it is not clear whether this is due to physical conditioning that increases



Fig. 5. Stress fracture of the mixed type. Three examples: (A) distal fibula and (B) distal femur reveal sclerosis with adjacent periosteal reaction. Fracture clefts are not seen; (C) distal second and fourth metatarsals. The former (left) shows both sclerosis and periosteal reaction, the latter (right) has linear clefts and sclerosis.

the strength of these bones, or to the fact that susceptible individuals have been assigned to sedentary type duties.

. Muscle pull appears to be important as witnessed by the occurrence of stress fractures in the fibula and other non weight bearing bones.

Pathologic material is very scarce. One of us (M.L.S.) has seen sections from a case which was biopsied. There was a great deal of internal and external callus and marked cortical bone resorption, but no fracture line. One could postulate that a hyperemia had caused resorption of the cortex with

subsequent weakening of the shaft. It seemed that the callus was forming in order to "shore up" the weakened cortex. This concept correlates well with the periosteal and sclerotic types in our classification. When this reinforcement is unsuccessful, the linear, fragmented and mixed types are produced. Muscle control is essential to enable the skeleton to bear the stresses imposed upon it. Perhaps muscle control or failure of muscle control is the determining factor.

#### SUMMARY

Stress fractures are everyday orthopedic problems in military basic training centers. We have classified these lesions as *linear*, periosteal, sclerotic, fragmentary and mixed. Typical examples of each are illustrated. A discussion of the clinical features of stress fractures is also presented.

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# CORTICAL BONE ATROPHY AND OSTEOPOROSIS AS A MANIFESTATION OF AGING\*

By H. E. MEEMA, M.D. TORONTO, ONTARIO

THE main roentgenologic interest in diagnosis of osteoporosis has until recently been focused on the spine, where recognition of rarefaction of the vertebral bodies has been considered to be the earliest sign of demineralization. However, it is now well established that a loss of 30-50 per cent of bone mineral from the vertebral bodies is required before an unequivocal roentgenologic diagnosis of osteoporosis can be made. This is due to several factors, such as considerable thickness and variability in the amount of soft tissue surrounding the spine, difficulty in standardization of the roentgen-ray exposure to yield comparable densities in various individuals and also in the same individual, and finally, quite marked normal variations in the architecture of cancellous bone tissue in different people.

The present work is an extension of a previous study<sup>8</sup> on the occurrence of cortical bone atrophy in old age and in osteoporosis. By means of a simple measurement of the cortical thickness of a peripheral bone, it may be possible in many cases to determine the presence of generalized osteoporosis. At the same time a rough semiquantitative estimate of the total loss of bone mineral can be obtained. This method is based on the assumption that in osteoporosis there is a comparable loss of bone from both the peripheral and the central skeleton. Such a concept is supported by the recent work of Urist and his co-workers12 in a comprehensive study of 6 patients with osteoporosis. Biopsy specimens from the bones of all 6 patients demonstrated that a reduction in bone mass occurred equally in both cancellous and cortical bone and not selectively in either. Thus the

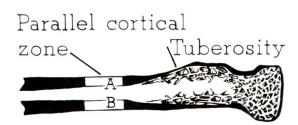


Fig. 1. Site of measurement of combined cortical thickness.

thickness of cortex was proportional to the total bone mass in an osteoporotic skeleton.

## MATERIAL AND METHODS

Routine roentgenograms of the supinated elbow were used for measurement of the combined cortical thickness (A+Bin Figure I) at the proximal end of the radius, just distal to the tuberosity. This site was selected because the endosteal and periosteal cortical outlines in this area were nearly always parallel for a distance of 0.5-1.5 cm. Thus comparable measurements were obtained in different individuals since the localization of the site of the measurement on the shaft of the bone in this manner is made independent of the size of the bone.

In order to obtain maximum accuracy of measurement, a pointed compass is used as shown in Figure 2. Cortex A is placed between the points of the compass. The distance a thus being fixed between the points, the compass is now moved over to cortex B, and one of the points is placed on its inner cortical border. While the other point remains fixed on the film, the point on the cortex is elevated and the compass is slowly opened until the loose point is accurately placed on the outer border of the

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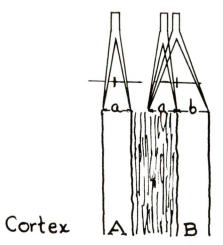


Fig. 2. Method of measurement of combined cortical thickness (explanation in text).

cortex B. The total distance (a+b) between the points is now measured on a millimeter ruler with an accuracy of  $\pm 0.5$  mm., only full millimeter values being recorded.

Measurement with pointed compass is more accurate than direct reading with ruler on the film, and since the use of the described method requires only one measurement off the millimeter scale, the error is smaller than would be the case if the two cortices were measured separately.

In addition to the cortical measurement, the total diameter of the bone is also recorded at the same site. Either the right or left radius is used for the measurement, since in a smaller control series no measurable difference was found between the two sides.

The material presented includes cortical measurements on a total of 1,588 different patients who for various reasons were referred for some roentgenologic examination at a large general hospital (Table 1). Of these, 1,344 patients were classified as "normals." Injuries to the elbow, comprising about one-half of the normal material, made up the largest single subgroup. The remainder of the normal group included patients with conditions other than osteoporosis or suspected osteoporosis. In this latter group, measurements revealed that the average cortical thickness was not significantly lower than that of the injury sub-

group. Therefore, the total "normal" material may be considered to embrace an average cross-section of the general population in regard to cortical bone thickness.

Those cases referred for investigation of back-ache were not included in the normal material. All cases with a clinical diagnosis of osteoporosis were listed separately in the "abnormal" group (Table 1). The remainder of the abnormals as listed in Table 1 was made up of cases of fractured hips (subcapital, transcervical, intertrochanteric), since osteoporosis is thought to be one of the etiologic factors in pathogenesis of these fractures. In all the "abnormal" cases an osteoporotic series was done routinely, including roentgenograms of the spine, pelvis, thorax, skull, and a lateral roentgenogram of the elbow.

In addition, in those cases where both the thoracic and lumbar spine were roentgenographed, notes were made of the presence and degree of any compression deformities of the vertebral bodies, and these were recorded together with the cortical measurements.

## RESULTS

The distribution of the combined cortical thickness in the normal material at the proximal end of the radius according to age groups in each sex is presented in Tables II and III. It is seen that there is an increas-

Table I

TOTAL MATERIAL AND ITS DIVISION
INTO DIAGNOSTIC GROUPS

Group	No. of Cases			
Injury	686			
Metastatic and skeletal survey	297	Total		
Urologic investigation	157	"normal"		
Chest and gastrointestinal investigation	100	1,344		
Others	104			
Clinical osteoporosis	67	Total "abnormal"		
Fractured hips	177	244		
Total		1,588		

ing number of individuals in older age groups who have thinner radial cortex than those in the young age groups of 21–45 years. Comparison of both sexes shows that thinning of the cortex begins earlier in the females, and the proportion of cases with marked cortical thinning in older age groups is also much higher in the female than in the male sex.

Table IV shows the mean values and standard errors of the combined cortical thickness for all the age groups in both sexes, calculated from Tables II and III. There are marked and statistically significant (P<0.01) changes in cortical thickness between each of the successive female age groups except for the two youngest age groups (21-45 years), where no significant difference is found. Thus the cortical thinning begins in the immediate postmenopausal period and progresses markedly in the 56-65 year group as well as in the older age groups. In the male material there is no significant change in cortical thickness from 20 to 55 years of age, but a reduction occurs after this period. The mean combined cortical thickness of the two age groups of 36-55 years is 6.76 mm. while the mean for the 56-65 year age group is 6.54 mm.; the difference between these means is statistically significant (P<0.05).

It is also apparent from Table IV that reduction in cortical thickness with age is greater in females than in males. The rates of reduction in cortical thickness were estimated to be  $0.67 \pm 0.04$  mm. per IO years for females and  $0.26 \pm 0.05$  mm. per IO years for males. Calculations based on com-

Table II

DISTRIBUTION OF COMBINED CORTICAL THICKNESS (CCT) ACCORDING TO AGE GROUPS
IN NORMAL FEMALES

Age Group No. of Cases	No.	No. of Cases with CCT of						
	mm.	3 mm.	4 mm.	5 mm.	6 mm.	7 mm.	8 mm.	
21-35	87				27	47	12	I
36-45	105				34	49	21	I
46-55	128		I	18	39	5 I	19	
56-65	136	2	8	50	44	28	4	
66-75	112	3	19	47	28	14	I	
76+	94	21	28	34	8	2	_	I

parison of the means of the 21–45 year age groups with those of the 76 and older groups reveal a total reduction in mean cortical thickness by 42 per cent in females and 13 per cent in males. Since there is no significant change in bone diameters with advancing age (Table v), the described cortical thinning must be entirely due to endosteal bone resorption, which is in agreement with some recent morphologic studies.<sup>2,7,12</sup>

As the smallest value for cortical thickness in the age of 21 to 45 in both sexes is 5 mm., any smaller values in the older age groups would always indicate the presence of cortical bone atrophy. The percentage of cases with such a measurable bone atrophy for each of 4 mm., 3 mm. and 2 mm. combined cortical thickness and for each age group is shown in Figure 3. If the cortical thickness is proportional to the total bone mass in an osteoporotic skeleton, 12 these small values would represent a certain

Table III

DISTRIBUTION OF COMBINED CORTICAL THICKNESS (CCT) ACCORDING TO AGE GROUPS IN NORMAL MALES

Age	Age No. of	No. cases with CCT of							
Group Cases	2 mm.	3 mm.	4 mm.	5 mm.	6 mm.	7 mm.	8 mm.	9 mm	
21-35	128				7	42	49	22	8
36-45	88				6	31	33	12	6
46-55	114			I	8	37	44	20	4
56-65	122			2	16	38	48	16	2
66-75	118			7	21	39	38	ΙΙ	2
76 <b>+</b>	112	3	5	9	17	31	37	8	2

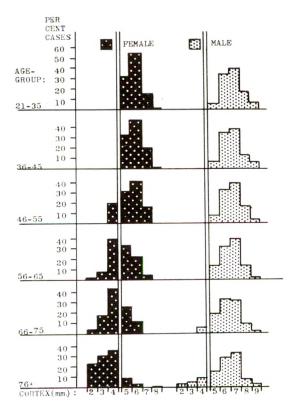


Fig. 3. Diagram illustrating age and sex distribution of combined cortical thickness.

measure of total bone loss from the skeleton in osteoporosis; *i.e.*, the values of 4 mm., 3 mm. and 2 mm. are to a certain extent indicative of the severity of osteoporosis. The theoretic losses in volume of cortical bone for each of these measurements, considering differences in bone diameters as well as the error of measurement, have been published previously. These merely confirm

what might already be concluded from the simple linear measurements; namely, that in a woman a combined cortical thickness of 4 mm. would likely represent a mild or borderline case of osteoporosis, while the measurements of 2-3 mm. should be considered to indicate the presence of severe osteoporosis. In men, however, a 4 mm. value has a somewhat greater significance. Since the percentage of males in the young age group of 21-45 years with a combined cortical thickness of 5 mm. is quite small, the 4 mm. value is more likely to indicate a loss of 2 mm. or 3 mm. of cortical thickness (if the original cortical thickness was 6 or 7 mm., respectively). Even a combined cortical thickness of 5 mm. may under these circumstances be compatible with considerable loss of bone, but this cannot be recognized by the present method.

Since in a previously published smaller series8 an impression was gained that cortical atrophy was more marked in old females with fractured hips than in the corresponding normal group, a re-analysis of that material was undertaken, the number of cases now being about twice that of the previous material. Instead of comparing the cortical thickness in the two total age groups of 71 years or older, it was now possible to divide each of these into three smaller age groups, and the results of the measurements are presented in Table vi. No significant difference is found in the mean values of combined cortical thickness between the cases of fractured hips and the

TABLE IV

RADIUS: DISTRIBUTION OF MEAN CORTICAL THICKNESS ACCORDING TO AGE

GROUPS IN NORMAL MALE AND FEMALE MATERIAL

		Males	Females		
Age Group	N	$m \pm s_m^*$ (mm.)	N	$m \pm s_m^*$ (mm.)	
21-35	128	6.86±.086	87	5.85±.074	
36-45	88	$6.78 \pm .106$	105	$5.90 \pm .073$	
46-55	114	$6.75 \pm .091$	128	$5.54 \pm .083$	
56-65	122	$6.54 \pm .089$	136	$4.74 \pm .085$	
66-75	118	$6.26 \pm .101$	112	4.30±.095	
76+	112	5.97 ± .137	94	3.43±.113	

<sup>\*</sup> Standard error of mean.

 $T_{ABLE}\ V$  radius: distribution of mean diameters according to age groups in normal material

A C	F	emales	Males		
Age Group	No. of Cases	$m \pm s_m \; (\text{mm.})$	No. of Cases	$m \pm s_m \text{ (mm.)}$	
21-35	87	12.0±0.12	128	14.9±0.15	
36-45	105	$12.1 \pm 0.10$	88	14.8±0.11	
46-55	128	11.9±0.10	114	15.1±0.13	
56-65	136	$12.1 \pm 0.10$	I 2 2	$14.9 \pm 0.12$	
66-75	112	12.0±0.10	118	14.8±0.13	
76+	94	$12.0 \pm 0.10$	112	$14.5 \pm 0.12$	

normals in any of the age groups over 71 years old. The higher percentage of lower values for the cases of fractured hips in the previous work was apparently due to the fact that there were proportionately more older females in the fracture group than in the normal group. An impression is thus gained that old women fracture their hips primarily because they have thin bones as a result of normal aging, and not because they are more osteoporotic than other old women of the same age.

Figures from Table II indicate that in the normal oldest female group of 76 years or older, about 51 per cent have a combined cortical thickness of 2 to 3 mm., while the corresponding percentage for the same male group (Table III) is only about 7 per cent. The ratio between these percentages is about 7:1; the same ratio has been found by Bauer<sup>5</sup> for fractures at the distal end of the

Table VI

COMPARISON OF MEANS OF COMBINED CORTICAL THICKNESS ACCORDING TO AGE GROUPS OF NORMAL FEMALES AND FEMALES WITH FRACTURED HIPS: 71

YEARS AND OLDER

	N	Vormal	Fractured Hips		
Age Group	No. of Cases	$m \pm s_m$ (mm.)	No. of Cases	$m \pm s_m$ (mm.)	
71-75 76-80	53 42	4.0±0.13 3.6±0.17	20	3.6±0.21 3.5±0.20	
81+	44	$3.1 \pm 0.15$	65	3.1±0.10	
Total 71+	139	3.6±0.11	114	3.3±0.09	

radius, while the corresponding ratio for fractured hips in his material was 3.5:1. However, since in his material the trauma causing the fracture of the neck of the femur was severe in about one-half of the male cases, while in women slight trauma was more than 6 times as frequent as severe trauma, the relative occurrence of marked cortical bone atrophy in old men and women is in good general agreement with the ratios of the incidence of these fractures.

Finally, an attempt was made to correlate the presence of cortical bone atrophy with that of osteoporosis of the spine. For this purpose the total material was used, the cases of osteoporosis or suspected osteoporosis and those with fractured hips thus being included. The only age group in which a large number of roentgenograms of the spine was available was that of the females over 65 years old. A total number of 309 cases were thus available for correlation of spinal osteoporosis with cortical bone atrophy.

As a definite criterion for osteoporosis of the spine, only compression deformities of the vertebral bodies were used, and only those cases having *definite* compression of two or more vertebral bodies (multiple compression) were classified as definite osteoporosis of the spine. As far as possible, vertebral compression due to other causes, such as secondary carcinoma and old traumatic fractures, were excluded from the material. However, it is realized, that in a few cases such exclusion was not possible. Likewise, in several of the cases excluded from the material on the basis of

Table VII

RELATIONSHIP BETWEEN CORTICAL THICKNESS OF THE RADIUS AND MULTIPLE SPINAL COMPRESSION IN FEMALES OVER 65 YEARS OLD

Combined Cortical Thickness (mm.)	2	3	4	5	6+
No. of spines examined No. of spines with mul-	44	92	86	32	14
tiple compression Per cent cases with mul-	19	29	4	-	-
tiple compression	43	31	5	_	-

having only one vertebral compression fracture, this was probably more often the result of osteoporosis rather than any other cause. Still, the division on basis of quantitation of spinal compression was considered to represent the relative occurrence of osteoporosis of the spine more accurately than an over-all roentgenologic estimation, including such uncertain criteria as the vertebral density on roentgenograms, vertical striation of the vertebral bodies, etc.

The number thus excluded from the total material was 41. Of the remainder 268 cases, 52 had multiple compression deformities of the vertebral bodies. The percentages of cases with multiple spinal compressions for each of the combined cortical thicknesses at the proximal end of the radius are given in Table VII. It appears that the frequency of occurrence of definite spinal osteoporosis (as previously defined) is in marked inverse relationship to the numerical value of the combined cortical thickness.

In the corresponding male age group the number of cases similarly analyzed was 179, and, although the number of cases with cortical thickness of 2 to 3 mm. was too small to allow any valid conclusions, the same general tendency of increased frequency of spinal compression with decreasing cortical thickness is apparent (Table VIII).

In view of the obtained results it does not appear likely that there are two different types of osteoporosis: peripheral and spinal. as suggested by Barnett and Nordin.<sup>3,4</sup> The fact that in a certain number of their cases with minimal biconcavity of the vertebral bodies the "peripheral bone score" (i.e., cortex/diameter ratio) fell within normal limits might largely be due to the insensitivity of their method of determination of peripheral bone atrophy. In order to evaluate such ratios as applied to the proximal end of the radius, these were calculated for each case in the present normal material and tabulated in the same manner as the combined cortical thickness in Tables II and III. Thus the smallest normal value was established on the basis of age alone (with the exception of only 1 female in the 36-45 year age group who had an abnormal ratio). The comparison of the percentages of abnormal ratios with those of abnormal cortical thickness with advancing age and in both sexes is given in Table 1x. It is seen that in the case of the radius the cortex /diameter ratio appears somewhat less sensitive than the simple cortical measurement for demonstration of cortical bone atrophy with advancing age. However, since this ratio follows the same general pattern as simple cortical measurement in relation to age and sex, it may be considered as an alternative method of determination of cortical bone atrophy. It would therefore have a similar inherent limitation as does the present method; namely, that low normal

 $T_{\rm ABLE~VIII}$  relationship between cortical thickness of the radius and multiple spinal compression in males over  $65~{\rm YEARS~OLD}$ 

Combined Cortical Thickness (mm.)	2	3	4	5	6	7+
No. of spines examined No. of spines with multiple compression Per cent cases with multiple compression	6 2 (33)	3 (25)	23 3 13	30 3 10	44	64

or borderline values do not exclude considerable losses of cortical bone. The occurrence of a certain number of normal ratios in cases with minimal vertebral compression is thus explained without the necessity to assume that spinal osteoporosis and peripheral osteoporosis are separate entities. Furthermore, the determination of minimal spinal biconcavity by means of measurement is often difficult as is emphasized by Barnett and Nordin.<sup>3</sup> Therefore, some of their cases classified as spinal osteoporosis may thus have been overdiagnosed.

#### DISCUSSION

Changes in the morphology of cortical bone with age have been documented by Iowsey<sup>7</sup> in a microradiographic study of the femoral cortex. It was shown that in young adults the haversian canals are uniformly small and there is little bone formation and destruction taking place. Later in life, the haversian canals increase in size with gradual formation of large cavities, particularly in the endosteal zone. Such an endosteal resorption of cortical bone will eventually result in thinning of the cortex, and the results of the present work indicate that, by means of a simple linear measurement on roentgenograms, it is possible to recognize the development of such cortical bone atrophy.

However, the true loss of cortical thickness cannot be determined by this method if the original cortical thickness is not known, as would be the case at the initial examination. Nevertheless, in cases where the cortical atrophy is very marked (a measurement of 2-3 mm. of combined cortical thickness at the proximal end of the radius), a considerable amount of bone mass must have been lost. If a corresponding loss is assumed to take place from the entire skeleton, as suggested by some recent investigations<sup>11,12</sup> and indicated in Tables ·vII and vIII of this work, the presence of generalized osteoporosis may thus be recognized provided that certain conditions resulting in long standing immobilization of the limb on which the measurements were made can be excluded. Osteoporosis can

TABLE IX

RADIUS: COMPARISON OF THE PERCENTAGES OF ABNORMALS DIAGNOSED BY MEASUREMENT OF CORTICAL THICKNESS AND CORTEX/DIAMETER RATIO

	Per Cent Abnormal Shown by						
Age Group	Cor Thick		Cortex/Diamete Ratio				
	M	F	М	F			
21-35	0	0	0	0			
36-45	0	0	0	I			
46-55	I	15	2	8			
56-65	2	44	0	31			
66-75	6	62	4	5 I			
76+	15	88	13	73			

thus be diagnosed in a number of cases where no spinal compression has yet occurred and when the other criteria for osteoporosis may fall short of being diagnostic.

Such an approach may be particularly valuable in cases where long term treatment with adrenal corticoid hormones is being planned. If at the initial examination a roentgenogram reveals the presence of definite cortical bone atrophy, extreme caution would have to be used, since spontaneous fractures following corticoid therapy are prone to occur particularly in patients with pre-existing osteoporosis.10 Thus a combined cortical thickness of 3-4 mm. in females and 4-5 mm. in males may necessitate modification of such treatments, perhaps by using smaller dosages or requiring addition of anabolic hormones to counterbalance the antianabolic action of corticoids. On the other hand, if a normal cortical thickness is found at the initial examination, it may be valuable to repeat the measurement at regular intervals. An unusually rapid development of cortical bone atrophy would again constitute a warning signal against continuation of unmodified corticoid therapy.

The use of cortical measurement in this manner for follow-up purposes could also be

adopted in other situations where it would be of interest to determine progressive loss of bone from the skeleton and particularly in research related to postmenopausal and senile osteoporosis.

Whether cortical bone atrophy also develops in osteomalacia in a similar manner as in senile osteoporosis has not been determined by this study. It is quite possible that some of the normal cases with cortical atrophy in the present series were suffering of subclinical osteomalacia, although there is no reason to suspect widespread malnutrition among the population in the area from which these cases were collected (metropolitan Toronto). Furthermore, the very pronounced difference in the development of cortical bone atrophy in the two sexes could hardly be explained by differences in diet alone. Nordin's assumption that the preponderance of osteoporosis among women could be explained by a calcium drain during pregnancy and lactation also fails to find support in this study. There is no difference in the mean cortical thickness between females in 21-35 and 36-45 year age groups (Table IV), and the considerable loss of the mean cortical thickness in the immediate postmenopausal group of 46-55 years as well as continuing losses with advancing age can hardly be explained as a result of the previous pregnancies, most of which take place in the 21-35 year age group.

The results of this work are in accordance with the original concept of Albright and Reifenstein; namely, that in the final analysis senile (and postmenopausal) osteoporosis is essentially a physiologic process in aging bone. The presented results are also in agreement with these authors' opinion that changes in production of gonadal hormones with age are of prime importance in development of senile osteoporosis. At the same time, they are quite compatible with a more recent modification of these theories by Reifenstein<sup>10</sup> in that an endocrine imbalance between gonadal and certain adrenal hormones would afford a better explanation on pathogenesis of osteoporosis than gonadal atrophy alone.

Such an agreement with these authors is in a way remarkable since in the present study peripheral bone was employed for determination of senile osteoporosis, while Albright and Reifenstein's well known concept of this condition is based on studies of the axial skeleton. The similarity of results in both cases as to age and sex distribution in osteoporosis would thus constitute supportive evidence that senile osteoporosis involves the cortical as well as the cancellous bone, the peripheral skeleton as well as the axial skeleton, and that losses of bone are probably of similar order. In addition, there is some evidence that the same involutional changes also take place in the skull and the clavicle.6

The question, whether senile osteoporosis occurs in all old people<sup>10</sup> may also be partially answered by studying Tables II and III (and Figure 3). It is obvious that cortical bone atrophy develops in nearly all females, although there is a notable exception of I case out of 94 in females 76 years or older in whom the combined cortical thickness had the maximal value of 8 mm. In males, however, the situation is entirely different. The mean cortical thinning in males throughout lifetime is about onethird of that in females (Table IV) and calculations based on information from Table III also indicate that only one-quarter to one-third of men develop any appreciable bone atrophy. In general terms, it may thus be stated that bone losses with aging can be recognized in more than 90 per cent of females as opposed to approximately 30 per cent in males; i.e., a sex ratio of approximately 3:1.

It follows also from these considerations that relative muscular inactivity in old age is not an important cause in development of osteoporosis. It would not explain the sex difference; on the contrary, since a bone of the upper extremity was used in this study, there should be less variation in degree of muscular activity in females with advancing age than in males, a greater proportion of whom may be assumed to have performed heavy physical work prior to retire-

ment. If inactivity were an important factor, the old men would thus develop osteoporosis more often than old women, which is not the case. Even if it is assumed that development of bone atrophy in males were entirely due to inactivity and if the degree of inactivity were similar in females and in males, then about two-thirds of females would still develop a bone atrophy which would require another explanation than muscular inactivity.

The difference in thickness of bony cortex in old men and women is of such a magnitude that, unless it would be considered as one of the secondary sex characteristics, the problem should be further evaluated by continuing research on the difficult subject of normal and abnormal aging since bone atrophy and osteoporosis would only seem to be one of its manifestations.

## SUMMARY

- 1. Measurement of cortical thickness at the proximal end of the radius on roent-genograms in 1,344 "normal" patients demonstrated a gradual thinning of the cortex with age in both sexes.
- 2. The onset of such cortical bone atrophy was easily demonstrable in the immediate postmenopausal period in females while in males it could first be detected in the 55–65 year age group.
- 3. The mean loss of cortical thickness throughout lifetime was found to be three times greater in normal females than in males.
- 4. A strongly positive correlation was found between the degree of cortical bone atrophy and osteoporosis of the spine.
- 5. The determination of cortical thickness at the proximal end of the radius was indicative of a significant loss of bone from the skeleton as a whole and thus helpful as an aid in diagnosis of osteoporosis.
- 6. A general impression was obtained
   that senile osteoporosis is primarily a manifestation of normal aging, and the marked difference found in its occurrence and development in males and females would sup-

port the view that changes in gonadal function with age are the most important single factor in its etiology.

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## ROENTGENOLOGIC ASSESSMENT OF FEMORAL NECK DENSITY AS RELATED TO FRACTURING\*

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HE subjective examination of roentgenograms by radiologists has indicated that a strong relationship exists between the roentgenographic appearance of the density of a bone and its susceptibility to fracturing, particularly noticeable in aged individuals with varying degrees of senile and postmenopausal osteoporosis. Because fractures of the hip constitute a large portion of the bone injuries which occur in geriatric individuals, the relationship between the density of the femoral neck as measured by roentgenographic bone densitometry and the ultimate yield loading has been investigated in the present study.

Many complications may occur in the recovery rate of the aged individual who falls and fractures the femoral neck. On this account, the ability to diagnose the extent of skeletal weakness in that anatomic site before the occurrence of a fracture would contribute materially to the protection of aged individuals. Therefore, one of the principal aims of this study has been to determine whether or not there might be a reasonable degree of predictability of bone strength as based on roentgenographic bone density measured quantitatively by the method described by Mack, Vose, and Nelson.<sup>3</sup>

## MATERIALS AND METHODS

Ten human femurs were obtained in order to determine the effects of density and morphology of the femoral neck on its resistance to axial compressive loading. All of the femurs had been removed from embalmed cadavers of both sexes, and, although the exact ages of the individuals

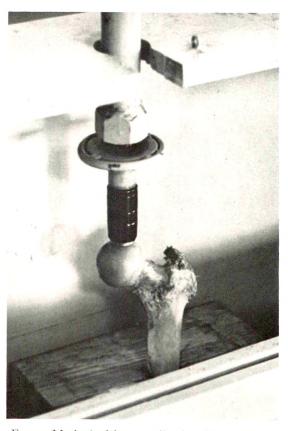


Fig. 1. Method of force application for fracturing femoral necks.

were not recorded, none was less than 60 years of age at the time of death.

Fracture Production of the Femoral Neck. In order to measure the breaking load when axial compressive force was applied to the head of the femur parallel with its shaft, the proximal one-third of each bone was supported vertically in a special housing and axial loading was applied until fracture occurred. The hydraulic testing device, which measured both the yield loading and the

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strain prior to fracture, has been described in an earlier report involving the analysis of pulverized, dry bone4 instead of the intact bone as described in the present investigation. The device consisted of a steel rack containing a cabinet with a transparent plastic observation window and a Black Hawk Porto-Power pump which applied force downward upon the bone through a steel plunger of adjustable length (Fig. 1). A 2,000 pound pressure gauge was used in the system. The proximal one-fourth of each femur was rigidly supported in a drilled hardwood block and force was applied at the rate of about 500 pounds a minute. A strain gauge, which was an integral part of the hydraulic plunger, indicated the maximum strain of the femoral neck at the instant of fracture. The reading was retained on the gauge until the scale was reset by the operator. The type of fracture whether transcervical or subtrochanteric also was noted. Prior to the application of force, both linear and volumetric dimensions were recorded for each femoral neck as well as the column-shaft angle.

Roentgenographic Analysis. Each femur was roentgenographed both before fracturing and immediately thereafter on no-

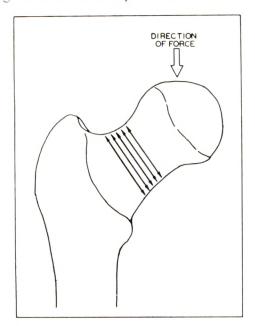


Fig. 2. Sites of photometric scanning paths across the femoral neck.

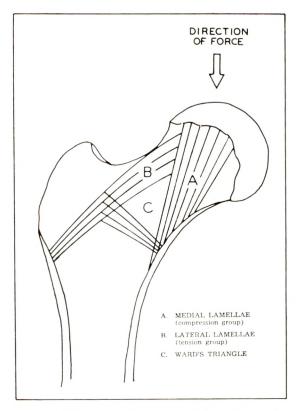


Fig. 3. Diagrammatic representation of internal weight-bearing system in the femoral neck.

screen film at 40 kv.—an energy sufficiently soft to produce maximum detail of internal structural lines within the neck. The photometric scanning system described in an earlier report3 was used to evaluate the roentgenographic density of the femoral neck. The system utilizes an aluminum allov calibration wedge which is roentgenographed simultaneously with the bone, and a specially modified scanning and recording device capable of correcting inherent nonlinearity of the roentgen-ray curve and of producing a digital count readout proportional to the absorbing mass of bone material. Roentgenographic bone density values derived by this technique represent the equivalent mass of bone mineral (in this case considered to be 3Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>·CaCO<sub>3</sub> which absorbs the same amount of roentgen radiation as the bone examined. Transcervical paths were scanned serially across each femoral neck as shown in Figure 2. Corrections for bone size were applied and sepa-

 $T_{\rm ABLE~I}$  results of tests involving axial compressive loading of femoral necks

Femur No.	Axial Yield Loading	Bending at Fracture (mm.)	Roentgen-ray Gram-Equivalents of $3Ca_3(PO_4)_2 \cdot CaCO_3$ per cc. of bone				
	(lb.)		Lateral Cortex and Lamellae	Ward's Triangle	Medial Cortex and Lamellae		
R-29	980	19	0.84	0.42	1.68		
L-29	1,320	12	1.00	0.36	1.53		
L-32	700	8	0.74	0.26	1.37		
R-33	1,480	18	0.98	0.39	1.77		
R-34	1,580	21	0.86	0.50	1.47		
L-34	2,250	22	0.80	0.51	1.35		
R-35	1,860	19	0.93	0.46	1.64		
L-35	1,660	20	0.78	0.39	1.66		
R-37	860	10	0.99	0.34	1.83		
L-37	1,240	14	0.96	0.32	1.59		

rate values were derived for: (a) the lateral cortex and lamellae, (b) the relatively porous Ward's triangle, and (c) the medial cortex and lamellae. The study was concerned with the density of a localized region of the femoral neck which does not necessarily correspond with a generalized decalcification of the bone as a whole.

## RESULTS

The results of tests involving axial compressive loading of femoral necks of the individual bones are summarized in Table 1. Although the table shows no relationship between the yield loading and the roent-genographically derived density of either the lateral or medial cortex of the femoral

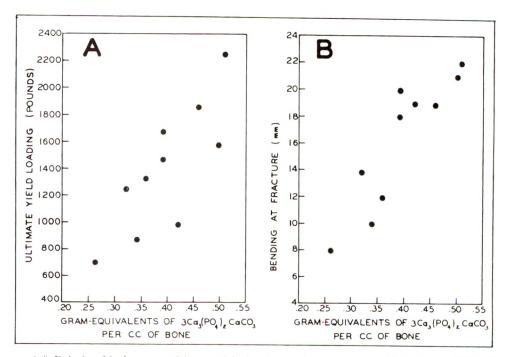


Fig. 4. (A) Relationship between ultimate yield loading and roentgenographic density of Ward's triangle. (B) Relationship between bending at fracture and roentgenographic density of Ward's triangle.

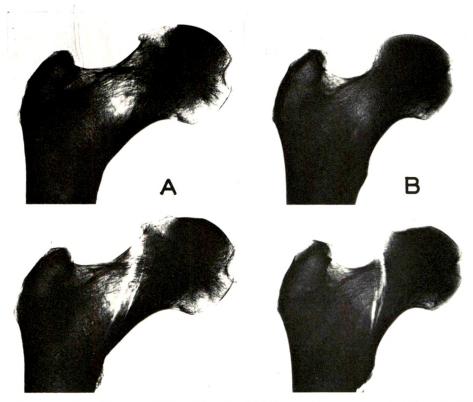


Fig. 5. Roentgenographic views of femoral neck which fractured at 700 pounds (A) and one which fractured at 1,660 pounds (B).

neck, the interlying area of relatively low density known as Ward's triangle (Fig. 3) has a conspicuous effect both on the ultimate yield loading and the degree of distortion at the instant of fracture. These relationships are illustrated graphically in Figure 4, A and B, which indicates that decreased density of Ward's triangle contributes to a similar decrease in ultimate yield loading of the femoral neck as well as a decrease in the degree of bending at the instant of fracture. A statistical treatment of the two variates reveals that the relationships are significant. The product moment coefficient of Ward's triangle density versus yield loading is 0.808 which is significant at the 0.01 level; and the correlation coefficient of Ward's triangle ver- sus strain at fracture is 0.771 which is also significant at the 0.01 level.

Figure 5A shows the extremely low density of Ward's triangle of femur No. L-32, which supported only 700 pounds of axial compressive loading—the lowest yield load-

ing of any of the bones tested. The opposite femur of the same individual could not be tested because it had been fractured before death and a femoral head replacement prosthesis had been applied. It can be postulated that the yield loading of the previously fractured femur must have been at least as low as its mate which was tested in the laboratory. The figures indicate that the produced fracture was transcervical through the lateral lamellae although it differs somewhat from the usual clinical fracture in that it is parallel to the medial lamellae instead of tangential to the axis of the neck.

Figure 5B shows initial and post fracture roentgenograms of a femoral neck (bone No. L-35) which withstood the comparatively high loading of 1,660 pounds before fracture occurred. In this case the roentgenographic density of Ward's triangle is conspicuously higher than that of bone No. L-32; and the density of cancellous bone is considerably greater.

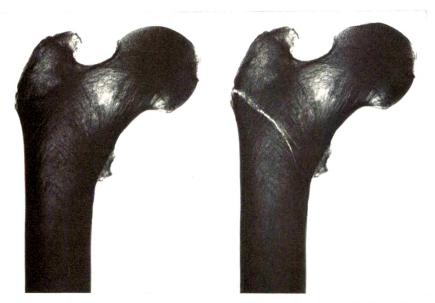


Fig. 6. Subtrochanteric fracture resulting from axial compression of the femoral head.

## DISCUSSION

The weight-bearing requirement of the femoral neck is one of the most severe of all the skeletal sites. Accordingly, this is reflected by the internal structural system of the bone. As shown in Figure 3, the femoral neck is basically a cantilever weight-bearing structure in which axial force is applied against a medial lamellae system projecting upward from the lower surface of the neck and diverging upon the articular margin of the head. Supporting the medial lamellae is the lateral system of lamellae, or tension group, which originates at the lateral femoral cortex, curving upward and medially to merge with the compression group.

When axial force is applied to the head of the femur parallel to the long axis of the bone, a transcervical fracture will ordinarily result. In such an instance the fracture passes across the lateral system of lamellae and runs parallel to the medial lamellae. The fractures illustrated in Figure 5, A and B are of the transcervical type. Instead of a transcervical fracture, a subtrochanteric fracture will sometimes occur even though the same conditions of force are applied which ordinarily will produce a transcervical fracture in the greater number of bones. A fracture of this type is demonstrated in

Figure 6. Preliminary examination of the inherent structural conditions which produce the subtrochanteric fracture when force is applied in the manner described indicates that an increased density of the lateral lamellae may be a contributing factor. In other words, if the lateral lamellae are sufficiently rigid to balance the axial force upon the medial lamellae, a fracture must occur at another site which is subtrochanteric in the cases which we have observed. In the 10 femoral necks studied, 4 of the fractures were of this type and were paired femurs from 2 individuals.

The type of transcervical fractures produced by axial force by the method described is somewhat different from the ordinary clinical fracture which usually occurs at right angles through the femoral neck. Hirsch and Frankel<sup>2</sup> have reported that the usual clinical fracture is a result of combined vertical compression applied to the head and axial force applied below the central axis of the neck. Nevertheless, since fractures resulting from a combination of vertical compression on the head and offcenter axial force, as well as vertical compression alone, both pass through the Ward's triangle in slightly different directions, it is probable that the density of this

region of relatively high porosity within the neck is a contributing factor under both types of loading.

Admittedly, many other variables in bone structure and composition will markedly affect its resistance to fracture under static loading. Among those investigated in the present study were: (a) the over-all size of the femoral neck; (b) the inclination of the femoral neck to the shaft; (c) the femoral score as determined by the formula of Barnett and Nordin<sup>1</sup> involving cortical thickness as a criterion of osteoporosis; and (d) the size and frequency of osteones in the proximal femoral cortex. At the present time, however, none of these variables has indicated a significant relationship with ultimate yield loading or the degree of elasticity of the femoral neck at the moment of fracture.

Although the bones used in this study were dissected at autopsy, similar roentgenographic measurements in the living individual do not appear to present insurmountable difficulties. In the case of osteopetrosis, which occurs with a frequency much lower than that of osteoporosis, the increased roentgenographic bone density contributes to a marked decrease in bone strength. In osteopetrosis, however, the strength loss is accountable to intrinsic differences in bone structure, while in osteoporosis it is accountable to changes in gross structure and morphology. The roentgenographic density-strength relationship described in this report obviously cannot be applied to sclerotic conditions.

#### CONCLUSIONS

- I. When a vertical loading is applied to the head of the femur until fracture occurs, the maximum yield loading tends to vary in accordance with the porosity of Ward's triangle; if the roentgenographic density is low, the ultimate yield loading is low and vice versa.
- 2. Whether the fracture is transcervical through the neck or subtrochanteric apparently depends on the inherent strength

of the lateral system of lamellae in the femoral neck. If the lateral lamellae have a high potential yield loading, the fracture tends to be subtrochanteric, whereas a transcervical fracture will occur if its potential yield loading is small.

3. Both the porosity of Ward's triangle and the density of the lateral lamellae can be evaluated roentgenographically, which indicates a favorable potentiality of predicting bone strength in the living human being.

### SUMMARY

The relationship between roentgenographically determined density of the femoral neck and its susceptibility to fracturing was determined for each of 10 human femurs. The porosity of Ward's triangle in each femoral neck was determined by roentgenographic bone densitometry, utilizing an aluminum alloy wedge and a linearizing recording densitometer, after which the proximal end of each bone was subjected to increasing axial compression until fracture occurred. A positive correlation was found between roentgenographic density of the femoral neck and (a) its ultimate vield loading and (b) its bending at the moment of fracture. The product moment coefficients (0.808 and 0.771, respectively) were significant at the 0.01 level.

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## DIFFUSE VILLONODULAR SYNOVITIS OF THE SHOULDER

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IFFUSE villonodular synovitis is one of a group of benign non-neoplastic lesions categorized under the comprehensive title of "pigmented villonodular synovitis, bursitis and tenosynovitis."4,5 The abnormality is uncommon but a sufficient number of cases have been studied to establish the clinical, pathologic and roentgenographic patterns. 2,3,4,6

The essential element of the pathologic picture is the proliferation of the lining tissues of the involved structures. Both the villi and nodules are covered by hemosiderin stained synovial cells. The spongelike supporting tissues of the villous lesions contain numerous round to polyhedral cells and multinucleated giant cells. Some of the cells are loaded with cholesterol, and hemosiderin is found both intra- and extracellularly. Many thin walled vascular channels are scattered throughout the tissue of the lesion. The larger nodules tend to be poor in cells but are heavily fibrotic and collagenized. The lesion varies in size from a pea size nodule to one filling an entire knee joint.1,4,5

Most of the cases of the diffuse form of pigmented villonodular synovitis have been found in the knee, but it has also been reported in the hip, elbow and ankle.<sup>2,6</sup> There is no known report of this condition being found in the shoulder. It is our purpose to describe 2 cases of pigmented villonodular synovitis involving the shoulder, each of which demonstrates salient features of this disease.

## REPORT OF CASES

CASE I. F.C., a 79 year old female, was admitted to Maimonides Hospital complaining of moderately severe pain in the left shoulder of 2 months' duration. In the previous 2 weeks she



Fig. 1. Case 1. Large hemispherical soft tissue mass extending from the acromion process down to the deltoid tubercle.

also noticed a mass in the same area. On examination the slightly tender mass over the anterolateral aspect of the left shoulder was cystic and slightly warm.

Roentgenographic studies in all projections showed normal osseous and articular structures (Fig. 1). A large spindle shaped homogeneous and sharply outlined soft tissue mass extended from the region of the coracoid process down to the deltoid tubercle.

At operation the subdeltoid mass measured approximately 3×7×11 cm. It was densely

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adherent to the surrounding tissues and was attached by a pedicle to the posterior aspect of the shoulder joint. The mass contained large cavities filled with blood clots, both recent and old. Histologic examination showed swollen villous projections lined by a double row of synovial cells. The villi were infiltrated with numerous hemosiderin laden macrophages and round cells. The pathologic diagnosis was "pigmented nodular synovitis."

Case II. L.O., a 21 year old female, was admitted to Kings County Hospital with the chief complaint of a painful tender mass in the left shoulder. Discomfort had been present for 6 months and had been increasing in severity. There had also been progressive increase in the size of the mass. On examination a firm tender mass 7 cm. in width was palpated over the head of the humerus. An additional 4 cm. mass was felt over the area of the bicipital groove.

Roentgenograms of the left shoulder (Fig. 2) showed a polycyclic pattern of destruction involving the entire head and tuberosities of the humerus but sparing the subarticular cortex. The average diameter of these cyst-like cavities was I cm. and all were sharply delimited by a thin sclerotic line. There was no reaction in the surrounding osseous structures. A small area of involvement was also present in the neck of the scapula adjacent to the coracoid process. The articular surface of the glenoid cavity was spared and the joint was normal in width.

At operation a large mass enveloped the long head of the biceps and extended over to the short head. The joint capsule was opened and tissue was curetted from the humeral head. Histologic sections showed villous and nodular structures invading bone. Interspersed through the villonodular structures were granulation and fibrous connective tissue containing pigment-filled macrophages, foam cells and multinucleated giant cells. The pathologic diagnosis was "pigmented villonodular synovitis."

## DISCUSSION

Pigmented villonodular synovitis is a difficult diagnosis to make on clinical or roentgenographic evidence in other than the classic case. It is a monarticular abnormality occurring most frequently in the third to fifth decades showing no sex predilection. There is an insidious onset of pain, swelling and limitation of motion



Fig. 2. Case II. Polycyclic erosions in head of humerus and in neck of the glenoid.

which usually becomes more severe with the passage of time.<sup>6</sup> However, there is disproportionately little discomfort compared with the extent of the lesion. In the involved joint nodular masses and synovial thickening may be palpable. Recurrent hemarthroses are impressive features of the disease and in the absence of trauma or hemorrhagic diatheses are of critical diagnostic significance.<sup>5</sup>

The roentgenographic patterns presented are variations of intra- and paraarticular soft tissue masses, joint effusions and erosions in bone.6 The soft tissue masses, when visualized, are smoothly outlined, homogeneous and never contain calcium. The osseous defects, which are found in the minority of cases, tend to be circular and when multiple present a whorled pattern.8 These cyst-like cavities are sharply circumscribed by a thin sclerotic rim. The bone between these lesions and in the subchondral zone is neither involved nor shows reactive changes. A highly characteristic feature is the involvement of both sides of a joint while sparing the joint itself. Periosteal changes do not occur nor is there regional demineralization. In the event of extensive disease or disease of long duration. erosion of the articular cartilage may occur with resulting arthritic changes.

## SUMMARY

Two cases of diffuse pigmented villonodular synovitis of the shoulder are presented. One patient showed the highly characteristic features of extensive osseous erosions on both sides of a joint surface while in the other there was a large soft tissue mass adjacent to the upper end of the humerus without bone or joint involvement.

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## UNILATERAL ANGIOMATOSIS\*

## ROENTGEN AND PATHOLOGIC FEATURES

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ANGIOMATOSIS is a systemic vascular anomaly, being either a telangiectasia, a hamartoma, or a true neoplasm. The term angiomatosis is also used in instances of mixed hemolymphangiomatosis, or more often in cases where the microscopic morphology of the vascular channels cannot definitely be called hematic or lymphatic.

Systemic angiomatosis with diffuse and particularly unilateral involvement of skeleton, soft tissue and viscera is rare.

Isolated angiomata, both hemangioma and lymphangioma, involving bone or other single organs, have been well studied roentgenographically and histologically. Combinations of cutaneous angiomata with other organ involvements have been described many times, and eponyms are generally used for their designation. Such syndromes are Parkes-Weber, Sturge-Parkes-Weber, Maffuci, Rendu-Osler-Parkes-Weber, Klippel-Trenaunay, and von Hippel's disease, to mention only a few.

The roentgenograms and biopsy specimens of a patient with extensive angiomatous lesions and hemigigantism, who has been seen at the University Hospitals for the past 10 years, have been recently reexamined. Systemic angiomatosis was diagnosed. This stimulated us to summarize the roentgen findings, describe a few unpublished roentgen signs, and discuss the pathologic features of angiomatosis.

## REPORT OF A CASE

The patient was seen for the first time at the age of 14, complaining of joint and back pain. His birth was apparently normal and he did not manifest any skeletal abnormalities until the age of 2. At that time he started to show a progressive overgrowth of the right side of the

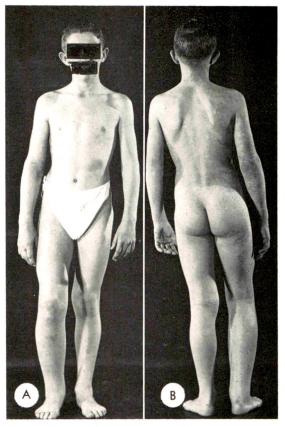


Fig. 1. (A and B) Photographs of the patient at the age of 15 showing a right unilateral gigantism involving the upper and lower extremities and due to angiomatosis. Multiple skin angiomata are present on the right side of the body. They are best seen on the back (B).

body, from the shoulder to the ankle. The right side of the body became covered by multiple reddish-blue macular patches which did not blanch on pressure. The neck, back, chest and abdomen were particularly covered with these patches, some of which crossed the midline. The skin lesions have persisted (Fig. 1, A and B).

During the first admissions to the hospital at the ages of 14 to 15, the patient was sub-

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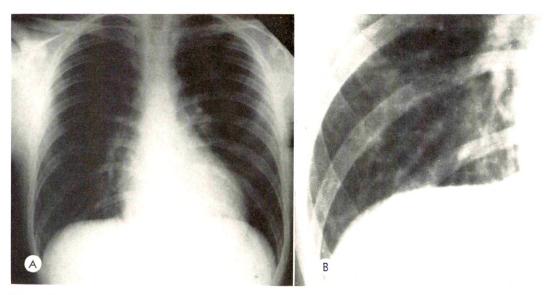


Fig. 2. Chest roentgenogram at the age of 14 (A) showing apparently normal heart and lungs. The patient did not present any pulmonary symptoms. A close-up view of the right lower lung field (B) shows a fine increase in the pulmonary markings representing interlobular septa.

jected to epiphyseal stapling of the distal femur and proximal tibia to help equalize the length of the lower extremities. A chest roentgenogram at that age (Fig. 2A) showed apparently normal heart and lungs. A closer study of the lung field shadows showed a fine increase in the pulmo-

nary markings, not only near the hili but stretched out to the periphery (Fig. 2B). This finding was not appreciated at the time.

The reason for a subsequent admission was an episode of pain in the right lower extremity accompanied by fever and local edema. The

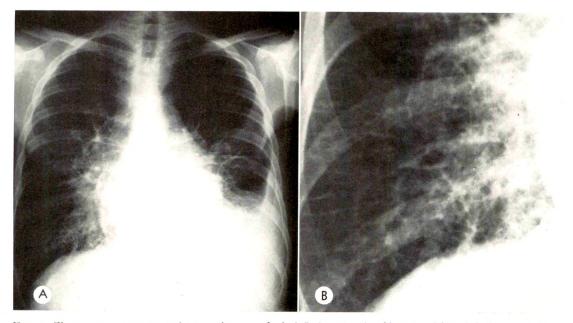


Fig. 3. Chest roentgenogram taken at the age of 16. (A) A network of increased interlobular septa is seen throughout the lung fields. They are more prominent near the hili and represent (based on the biopsy) fibrotic septa containing enlarged vascular spaces. A close-up view (B) shows the markings in detail. The left hemothorax is due to the exploratory thoracotomy and was resorbed in a few days.

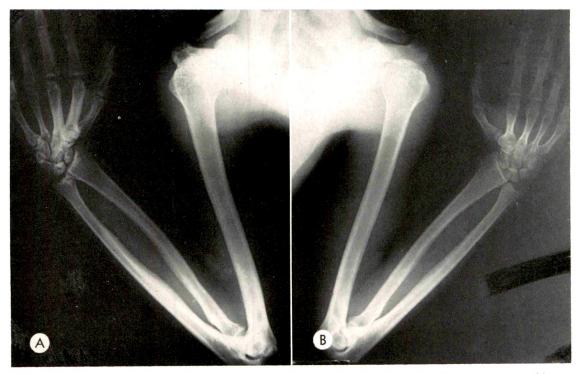


Fig. 4. Anteroposterior roentgenogram of both upper extremities demonstrating the roentgenographic appearance of unilateral angiomatosis (A) as compared to the normal side (B). Note the increase in the size of the bones, the thickening of the cortex and the areas of radiolucent sclerotic lesions of the acromion, glenoid fossa and epiphyses of the humerus and radius.

edema spread from the costal margin to the crest of the ilium, continuous with that of the genitalia and right lower extremity. The diagnosis of lymphangitis was advanced and the acute symptoms subsided under antibiotic treatment. A lymphedema of the right side of the body, right lower extremity and genitalia has persisted. Several small angiomata of the penis and scrotum were observed during one of the subsequent clinic visits.

At the age of 16, while out of the hospital, the patient had an episode of pulmonary infection following an apparent exposure to sulfur fumes. The episode was accompanied by fever and hemoptysis. One year later the patient returned to the clinic because of shortness of breath on exertion, with occasional blood streaked sputum. Clinically, he presented cardiac enlargement, a pericardial friction rub and an enlarged liver. The right lower extremity had a circumference of 4 to 14 cm. more than the left side, the larger measurement being for the thigh. The right arm veins were distended.

The chest roentgenogram (Fig. 3A) showed a slight cardiac enlargement and a fine network

of horizontal and vertical fibrotic lines crossing each other and leaving in between them cystic-like areas of lung parenchyma. These lines were most prominent near the hili but stretched out to the periphery. Their detail was best seen in the costophrenic angles (Fig. 3B). The skeletal survey showed normal bone structures except for the right upper and lower extremities (Fig. 4, A and B). The right upper extremity (Fig. 4A) showed a diffuse enlargement of all structures including the clavicle and the scapula. The enlargement was due mostly to increased thickness of the cortex. There were areas of peculiar mixed radiolucent sclerotic elements involving the acromion, glenoid fossa, and the epiphyses of proximal and distal humerus and radius. The soft tissues were increased in size.

The roentgenograms of the hands (Fig. 5, A and B) showed radiolucent sclerotic areas in better detail. The carpal bones, the bases of the phalanges and the bases and heads of the metacarpals were involved. Small cystic-like radiolucencies were mixed with small islands of bone sclerosis (Fig. 6). In addition, there

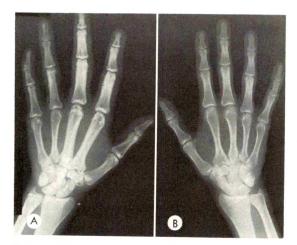


Fig. 5. Roentgenograms of the hands showing a gigantism of the right hand (A) as compared to the normal left hand (B). The carpal bones, the epiphyses of the metacarpals and the bases of the phalanges show the mixed areas of cystic radiolucencies and bone sclerosis as seen in the right clavicle, humerus and radius.

was localized gigantism of the right hand and all bones had a thickened cortex.

A roentgenogram of the thighs (Fig. 7) showed an increase in soft tissue density on the right side. The soft tissue of the inner thigh and scrotum had a wormy appearance with transverse and vertical lines somewhat similar to the fibrotic lines in the chest (Fig. 2B). There was an increase in density of the femur probably produced by cortical thickening.

The roentgenogram of the legs (Fig. 8) showed an increase in soft tissue thickness of the right leg, one-third more than the soft tissue thickness on the left side. The cortex of the tibia was thickned, giving a sclerotic appearance to the tibial bone.

The patient was subjected to an exploratory thoracotomy with lung and pericardial biopsies. The lungs were described as having grossly a marked prominence of the lobular pattern. On palpation, the surgeon had the sensation of touching vessels with thick walls. The pericardium was found to be adherent to the epicardium with only a minimal amount of fluid. There was no evidence of pericardial constriction.

Lung biopsy (Fig. 9) showed fibrosis of the interlobular septa and of the pleura. Numerous vascular spaces of varying size were present in the fibrous areas. They were optically empty, their walls were well defined and consisted of

muscle and fibrous tissue with abundant elastic fibers. The distribution of the vascular channels did not follow a clear-cut pattern. It was not possible to identify the exact nature of these channels, that is, whether they were blood or lymph vessels.

Pericardial biopsy revealed fibrosis of the pericardium and pericardial fat with vascular spaces similar to those seen in the lung. The spaces were frequently arranged in clusters, some quite large and on occasion containing valves.

The patient recovered quickly from the surgical procedure.

At the age of 18 he developed cellulitis of the right thigh, with severe edema of the leg, penis and scrotum. This subsided, leaving the previously described residual edema.

Two years later the patient was re-admitted for plastic surgery to the penis and scrotum. The procedure was considered successful. Skin removed from the penis and scrotum was examined microscopically (Fig. 10, A and B), and found to be thickened, fibrosed, and containing large vascular spaces similar in all respects to those described in the lung and pericardium. Most spaces were optically empty and red blood cells were found only rarely and in small



Fig. 6. Magnified roentgenogram of the right carpal bones demonstrating in detail the peculiar mixture of cystic-like radiolucencies and sclerotic bone islands, believed to be due to an imbalance of bone formation and reabsorption as a result of the increased blood and lymph flow in the abnormal vessels.

numbers. Sometimes groups of these vascular channels were seen accompanying an artery, and it was then not possible to identify whether they were all venous or whether one was a vein and all others lymphatics.

When last seen, the patient presented himself with the already described skeletal asymmetry, with lymphedema of the right lower extremity, and with the cutaneous angiomata. The chest roentgenogram showed persistent thickening of the septal lines and a slight cardiomegaly.

#### COMMENTS

Aside from the striking clinical and roentgenographic features, the reported case is interesting in view of the nature of the vascular lesions. Biopsies proved their presence in the lung, pericardium and skin. Unfortunately, the skeletal lesions were not biopsied and we have to rely solely on the roentgenographic appearance to tie all the findings into a systemic angiomatosis.

The patient's condition, although congenital, manifested itself later in life and most of the currently involved tissues did not show gross angiomatous changes until

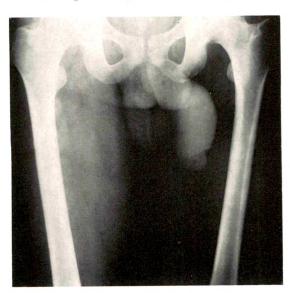


Fig. 7. Roentgenogram of the thighs showing a dense right femur and a significant increase in soft tissue volume of the thigh, scrotum and penis. Note transverse fibrotic lines embedded in the subcutaneous fat and representing (according to the biopsy) fibrotic strands containing abnormal vascular spaces.

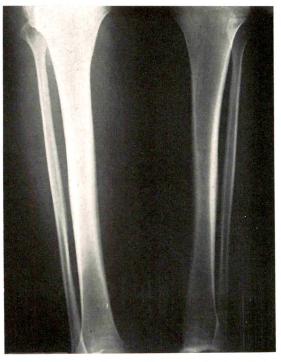


Fig. 8. Roentgenogram of the legs showing an increase in the size of the tibia and fibula due to cortical thickening accounting for the increase in bone density.

an inflammation occurred and made the involvement obvious clinically and roentgenographically. His disease has remained stable for the past 3 years and no further worsening of his condition is anticipated unless new inflammatory processes should develop.

## ROENTGEN MANIFESTATIONS

The roentgen changes of pulmonary angiomatosis are not well documented in the literature. Massive hemangioma of the lung was reported by Caffey.<sup>2</sup> Complications of pulmonary and pericardial angiomatosis were described respectively by Koblenzer and Bukowski,<sup>14</sup> and Miller *et al.*<sup>18</sup> In these instances, the patients expired with chylothorax<sup>14</sup> and chylopericardium.<sup>18</sup>

In diffuse involvement of the lungs, as in our case, the angiomatous changes are seen on the roentgenogram as a fine network of septal lines. Normally, the interlobular septa are not visible.<sup>5</sup> They become percep-



Fig. 9. Microscopic section of the lung biopsy obtained during exploratory thoracotomy showing fibrosis of the interlobular septa containing vascular spaces of various sizes, one with considerable muscle in its wall.

tible when engorged or fibrotic. The Kerley A, B and C lines are well known. In cases of angiomatosis the septa become visible because they are fibrotic and contain a large number of abnormal vessels. In instances of an inflammatory process superimposed on the angiomatosis, the fibrous tissue in the septa makes them even more visible on the roentgenogram. The fine septal network (Fig. 3B) consists of horizontal and vertical lines crossing each other and leaving between them cystic-like spaces of lung tissue. Near the hili the lines are more prominent and fade slightly toward the periphery.

Similar roentgen findings can be seen in carcinomatosis, lymphoma, primary hemosiderosis, pneumoconiosis, interstitial fibrosis, sarcoidosis, reticulocytosis, scleroderma, after ligation of the thoracic duct,<sup>5</sup> and in xanthomatosis and histiocytosis X.

The pericardium involved with angiomatosis presents as an apparent cardiac enlargement on the roentgenogram due to the thickening of the pericardium, but there is decrease of pulsation of the cardiac border.

Unilateral gigantism as seen in angiomatosis is different from the congenital hypertrophy of one side of the body. In the latter condition<sup>2</sup> half of the head, thorax, abdomen, pelvis and extremities are involved and this localized gigantism gradually disappears during early adult life. Localized gigantism, particularly in extremities and due to an increase of blood or lymph supply to the growing cartilage, has been reported in the literature.<sup>2,11,13,16,19,27</sup>

The roentgen features of unilateral gigantism as seen in angiomatosis are first of all a generalized increase in the size of the involved extremities (Fig. 4–7, inclusive). There is an increase in both length and width. It appears that the increase in width is produced by the thickening of the cortex. This was also observed by Caffey.<sup>2</sup> Localized gigantism can be seen also in chronic arthritis, healing fractures, regional arteriovenous fistula, chronic hemophilic hemarthrosis and in infantile cortical hyperostosis.

The skeletal changes in hemangioma and lymphangioma are very well documented in the literature.<sup>2,4,6,10,11,23,24,27</sup> In special reference to the generalized type of angiomatosis, Caffey<sup>2</sup> stresses the cystic-like defects of various sizes in the tubular bones near the ends of the shafts. In Sherman and Wilmer's23 review of angiomatosis, cysticlike expansion of the phalanges and metacarpals with disappearance of the phalanges is mentioned. Discussing particularly lymphangiomatous changes in bone, Shopfner and Allen<sup>24</sup> state that the lesions are invariably lytic and well defined and no surrounding sclerosis is present. The rest of the authors<sup>2,11,23</sup> report, in connection with isolated hemangioma or lymphangioma, a · variety of cystic lesions, from small to large, and even complete disappearance of the bone, also known as Gorham's syndrome.6



Fig. 10. Microscopic sections of skin of scrotum. The thick fibrosed skin contains large vascular spaces similar to those in the lung, one with partly muscular wall. Note the presence of valve-like structures in the lumen (A), medium-sized and small spaces in the dermis, with angiomatous features (B).

In our case we find a roentgenographic appearance of angiomatosis not reported to our knowledge. Contrary to other cases, in our instance the epiphyses are involved by a mosaic pattern of alternation of small radiolucent areas with small islands of bone sclerosis (Fig. 5B). The lytic areas are similar to the ones described by others in hemangioma or lymphangioma. The sclerotic islands have an appearance similar to the bone islands seen in osteopoikilosis. A speculative explanation for this variety would be that there is a rich blood and lymph supply to the epiphyses by the abnormal vessels. This could disrupt the balance between bone formation and bone absorption.6 The dense spots are probably thick and dense bone trabeculae as in osteopoikilosis,25 or small infarcts produced

by pressure of the abnormal vessels.

All parts of the skeleton can be involved in angiomatosis. Skull, vertebrae, pelvis, clavicle and scapula have all been reported to be involved. 16,20,22

In the differential diagnosis of the roentgen manifestation of the skeleton by angiomatosis, the following conditions have to be mentioned: generalized fibromatosis, storage reticulosis, neurofibromatosis, neuroblastoma, polyostotic fibrous dysplasia and generalized lipomatosis.

The soft tissue involvement by angiomatosis is seen on the roentgenograms as an increase in size of muscles and subcutaneous structures. Individual vessels can be seen embedded in the subcutaneous fat (Fig. 6).<sup>3,9,23</sup> Round shaped calcifications in the soft tissue are occasionally seen.<sup>9,23</sup> They

represent phleboliths and are related to a venous component if such is present in angiomatosis.

#### DISCUSSION

The use of the term angiomatosis in our case is certainly open to question since this term implies a diffuse neoplastic process of blood or lymph vessels. The vessels in this case were enlarged but there was little evidence of actual proliferation of the vascular elements. A better term for such a lesion may be telangiectasis, as advocated by more than one author.<sup>17</sup> Telangiectases may extend and grow in size possibly by sheer dilatation of their spaces with secondary multiplication of well differentiated endothelial cells. Distinction from a true tumor with primary proliferation of endothelial cells and consequent increase in the size or number of vascular spaces may be easy in some instances, problematic or even impossible in others. 7,8,26 This may also be true for a congenital malformation or hamartoma. Confusion may also arise with arteriovenous fistulae.3,21

Although usage seems to sanction preference for the term angiomatosis, it should be kept in mind that many cases of angiomatosis are hamartomas and others are telangiectases and not true neoplasms.

On the other hand, the use of the term angiomatosis as opposed to hemangiomatosis or lymphangiomatosis may be considered as an indication of the presence of both blood and lymphatic vessels. It is often used with this meaning.14 However, it is difficult and sometimes impossible morphologically to differentiate lymphatic from hematic channels. Dilated vascular spaces may have walls compatible with those of blood vessels, particularly veins, as well as with lymphatics. As Kaindl and co-workers<sup>12</sup> have shown, even normal lymphatic channels may be indistinguishable from venous vessels. This would apply more strongly for pathologic vascular spaces. Therefore the term angiomatosis could reflect this difficulty experienced by studying biopsies. Angiomatosis can stand as it is in our case,

for an entity of hematic, lymphatic or uncertain nature composed either of previously present dilated vessels or abnormal vessels resulting from a developmental error or even a true neoplasm. This definition could explain the large variety of lesions seen histologically and roentgenographically and called by different authors hamartomatous hemolymphangiomatosis, <sup>14</sup> cystic angiomatosis, <sup>10</sup> ectomesodermic hamartoma, <sup>1</sup> angioma with metastasis, <sup>22</sup> multiple lymphangiectasis, etc.

#### SUMMARY

A rare case of systemic angiomatosis with unilateral skeletal, soft tissue and visceral involvement is reported. The roentgen manifestations of angiomatosis are reviewed with a presentation of a few unpublished signs in lung and bone involvement. The pathologic aspect is discussed and an attempt is made to define more clearly the term angiomatosis.

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Finance and Budget Committee: T. F. Leigh, Atlanta, Ga.; E. L. Pirkey, Louisville, Ky.; C. B. Holman, Rochester, Minn.; J. A. Campbell, Indianapolis, Ind.; W. Bailey, Chairman, Los Angeles, Calif

Committee on Scientific Exhibits: R. R. Greening, Philadelphia, Pa.; J. S. Dunbar, Montreal, Que., Canada; L. E. Etter, Chairman, Pittsburgh, Pa.

Representatives on the American Board of Radiology: C. A. Stevenson, Spokane, Wash.; J. F. Roach, Albany, N. Y.; C. A. Good, Rochester, Minn.

Director of Instructional Courses: H. O. Peterson, Minneapolis, Minn.; Manager of the Annual Meeting: J. C. Cook, 110 Professional Building, Detroit 1, Mich. Editor: T. Leucutia, 110 Professional Building, Detroit 1, Mich.

Sixty-fourth Annual Meeting: Queen Elizabeth Hotel, Montreal, Quebec, Canada, October 8–11, 1963.

## AMERICAN RADIUM SOCIETY

President: Charles G. Stetson, Tenafly, N. J.; President-Elect: Joseph H. Farrow, New York, N. Y.; Ist Vice-President: Juan A. del Regato, Colorado Springs, Colo.; 2nd Vice-President: John L. Pool, New York, N. Y.; Secretary: Justin J. Stein, Los Angeles, Calif.; Treasurer: Milton Friedman, 1016 Fifth Ave, New York 28, N. Y.

Executive Committee: Jesshill Love, Chairman; Robert L. Brown; Gilbert H. Fletcher; Charles G. Stetson; Justin J. Stein; Joseph H. Farrow; Juan A. del Regato; John L. Pool; Milton Friedman.

Scientific Program Committee: Charles G. Stetson, Chairman; A. N. Arneson, St. Louis, Mo.; Milton Friedman, New York, N. Y.; Harold E. Johns, Toronto, Ont.; Henry S. Kaplan, Palo Alto, Calif.; Calvin T. Klopp, Washington, D. C.; Milford D. Schulz, Boston, Mass.; Joseph H. Farrow, Ex officio.

Committee on Arrangements: Henri LeClaire, Chairman, Cincinnati, Ohio; Manuel Garcia, Chairman Designate, New Orleans, La.; Albert L. Allen, Huntington, W. Va.; Robert D. Berkebile, Elyria Ohio; H. Peter Mueller, Belmont, Mass.; Ralph M. Scott, Louisville, Ky.; Milton Friedman, Ex officio.

Publication Committee: Harry Hauser, Chairman, Cleveland, Ohio; Wendell C. Hall, Hartford, Conn.; Martin Van Herik, Rochester, Minn.

Public Relations Committee: H. Peter Mueller, Chairman, Belmont, Mass.; Harold W. Jacox, New York, N. Y.; Charles H. Peterson, Roanoke, Va. Janeway Lecture Committee: Edith H. Quimby, Chairman, New York, N. Y.; William S. MacComb, Houston, Tex.; Clifford L. Ash, Toronto, Ont. Representatives on the American Board of Radiology: Frederick W. O'Brien, Boston, Mass.; Bernard P. Widmann, Philadelphia, Pa.; Donald S. Childs, Jr.,

Representatives on the National Committee on Radiation Protection: Robert Robbins, Philadelphia, Pa.; • Herbert M. Parker, Richland, Wash.

Representative on the Board of Chancellors of the American College of Radiology: Milford D. Schulz. Forty-sixth Annual Meeting: Greenbrier Hotel, White Sulphur Springs, W. Va., April 13–16, 1964.

Rochester, Minn.

## ≈ EDITORIALS ∞

## THE FORTY-FIFTH ANNUAL MEETING OF THE AMERICAN RADIUM SOCIETY

THE American Radium Society held its Forty-fifth Annual Meeting in San Francisco April 1–4, 1963 at the Mark Hopkins Hotel. The attendance of members and guests was almost that of the 1962 meeting with a total registration of 517, representing 135 members, 231 non-member guests and 151 ladies. On Sunday evening prior to the meeting, a special Gray Line Tour of the City was taken by two bus loads of the early arrivals. The weather was cool and crisp affording a breath-taking view of different parts of the City and Bay area from Coit Tower on Telegraph Hill to Sausalito across the Bay.

The meeting was officially opened on Monday morning, April 1, in the Peacock Court of the Hotel. Dr. Jerome M. Vaeth, Chairman of the Committee on Arrangements, welcomed all those in attendance to his attractive and interesting City which twice in the past was the host city for the annual meeting of the American Radium Society. Dr. Gilbert H. Fletcher of Houston delivered the Presidential Address in which he discussed the impact of biomathematics on medicine. He stated that until the recent past, medicine was essentially descriptive because biology itself was a descriptive science. A revolution has occurred in that biology is being transformed from a descriptive to a quantitative science. Dr. Fletcher mentioned two milestones in the revolution of information processing. The first was the publication in 1925 of Sir Ronald Fisher's book "Statistical Methods for Research Workers" and the second the development of automatic computers in the 1940's. Both of these events are bringing to our civilization a change, the impact of which is immeasurable and can be compared to the impact of the technologic revolution. The membership of the American Radium Society is composed of surgeons, internists and radiotherapists, all of whom are interested in the definitive treatment of cancer patients with tangible end results. Among them are physicists and radiologists who, by their training and scientific pursuit, are quantitatively minded. Thus, among medical societies, the American Radium Society is the best equipped to meet the challenges wrought by these new technologies.

The first scientific session under the chairmanship of Dr. Justin J. Stein consisted of presentations on lymphography; the place of radiotherapy in the treatment of tumors of the base of the tongue; combined chemotherapy and irradiation in advanced squamous cell carcinoma of the head and neck; and some first remarks about statistics and cancer therapy. The second part of this session was a symposium arranged by Dr. Henry S. Kaplan of Stanford University on the subject of "The Fundamentals of Radiobiology." Dr. J. W. Boag of Middlesex, England, spoke on the primary processes in radiation chemistry and radiobiology. Dr. Kaplan dealt with his investigation on the biochemical basis of reproductive death in irradiated cells, followed by Dr. J. E. Till of Toronto, who related his researches on the quantitative aspects of radiation lethality at the cellular level. Dr. Harvey M. Patt of the Argonne National Laboratory elucidated on his work on the quantitative aspects of radiation effects at the tissue and tumor level.

During the morning following a coffee hour in the Florentine Room sponsored by the Bush Electric Company, the ladies were entertained by a special bus tour through the City of San Francisco and environs. In the evening, the Radium Chemical Company was host to the Society by sponsoring a reception at the attractive St. Francis Yacht Club overlooking the Bay near the Golden Gate Bridge.

Dr. Jean Bouchard was chairman of the second scientific session, the first part of which was a symposium on "Lymphomas." Dr. James J. Nickson of New York Memorial Center introduced the 4 speakers. Dr. Robert J. Lukes spoke on the relationship of the histologic features to the clinical stages in Hodgkin's disease. He classified Hodgkin's disease into 5 distinct histologic types after reviewing 3,000 cases at the Armed Forces Institute of Pathology. These included the (1) lymphocytic-histiocytic nodular and diffuse, (2) nodular sclerotic, (3) mixed, (4) diffuse fibrotic and (5) reticular types. Dr. Alan C. Sheer reviewed the clinical course of 200 patients with Stage I of equal numbers of Hodgkin's disease, lymphosarcoma and reticulum cell sarcoma following treatment. He emphasized the importance of prophylactic treatment of clinically uninvolved areas. Dr. M. Vera Peters outlined the contribution of radiotherapy in early lymphomas by relating her statistics in 414 patients with lymphosarcoma, reticulum cell sarcoma and giant follicular lymphoma from 1934 to 1952. Survival rates of from 1 to 20 years were given for each group. Dr. David Karnofsky stressed the role of chemotherapy in the management of Hodgkin's disease by stating that various agents used in appropriate situations may be effective in relieving certain manifestations. The second part of the morning session was opened by Lucille A. DuSault who presented her continuing researches on the influence of time-spacing of fractions on the response to radiation. She stated that, since daily fractionation in practical radiotherapy has gaps of 2 or 3 days over week-ends, timedose curves actually show that doses of 8,000 r to CH<sub>3</sub> mice mammary carcinoma are just as effective when given 3 times a week over a 4 week period. Other presentations included postoperative treatment of 260 patients with breast carcinoma with

2 mev. techniques; results of ultra-fractionation radiotherapy in breast carcinoma; and a description of a method and results of treatment of breast carcinoma with  $Co^{60}$  teletherapy.

The highlight of the meeting came at the close of the Tuesday morning session with the presentation of the Annual Janeway Lecture. Dr. William S. MacComb introduced the lecturer with the warmth and affection of a long-time friend and reviewed some of his investigative work and the many responsible medical positions which he has held in the past. Dr. A. N. Arneson of Washington University School of Medicine of St. Louis spoke on "Long Term Observation in Endometrial Carcinoma." He reviewed the techniques used in various centers, spoke on the etiologic factors related to endometrial cancer and analyzed his experience in the management of these malignant lesions in a series of 173 private patients. He concluded that equal results could be obtained by surgery alone as well as by irradiation plus surgery in the Stage 1 cases with a small uterus and differentiated tumor, but that considerable improvement in salvage could be achieved by the combination treatment in patients with a large uterus and undifferentiated tumor. The mechanism for better results by the combined method of treatment is purely speculative according to the lecturer.

On Tuesday afternoon, a Radiation Therapy Clinic was held at the University of California Medical Center. Dr. Franz Buschke introduced Dr. Manuel Lederman of London, who conducted the clinic on 4 patients with carcinomas of the upper digestive tract and upper respiratory tract. Dr. Jerome M. Vaeth acted as chairman of the clinic and presented the case histories including the radiotherapy previously administered and the present status of the patients' condition. Considerable discussion took place. Following this clinic, several members of the group visited Dr. Robert S. Stone's Radiological Laboratory, famous for its 70 mev. synchrotron.

The social events of the day included a bus tour by the ladies to Saratoga to visit the winery of Paul Masson. In the latter part of the afternoon and early evening, a sunset harbor tour was attended by many members and their wives. The hosts for this boat tour were the Atomic Energy of Canada and the Allis Chalmers Manufacturing Company.

The third scientific session on Wednesday morning was held under the chairmanship of Dr. Jerome A. Urban. A symposium on "Protraction and Fractionation" was presented by 4 essayists following introduction by Dr. Franz Buschke who arranged this symposium. Dr. F. Baclesse spoke on ultraprotraction; Dr. D. K. Sambrook on split-course technique; Dr. Charles Botstein on periodic fractionation; and Dr. Harold L. Atkins on massive single dose technique. The second part of the Wednesday morning session was a symposium on "Preoperative Irradiation" arranged by Dr. Milton Friedman. Following introductory remarks by Dr. Friedman, Dr. Isadore Lampe spoke on preoperative irradiation in endometrial carcinoma; Dr. Edgar C. White on cancer of the breast; Dr. Willet F. Whitmore on cancer of the bladder; Dr. Fernando G. Bloedorn on cancer of the lung; and Dr. Sidney M. Silverstone on advanced cancer of the laryngopharynx. A lively discussion followed these presenta-

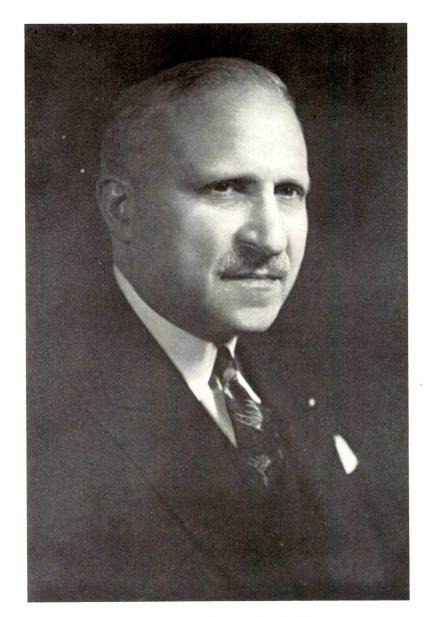
Two scientific tours were provided for members and guests during the Wednesday afternoon hours. One group was transported to Palo Alto, where Dr. Henry Kaplan explained the activities of the Department of Radiation Therapy at Stanford University Medical Center and demonstrated the various sections of this unusual research, educational and treatment center. Part of this group also visited Varian Associates plant, where the new 6 mev. linear accelerator is manufactured. The other group traveled to Berkeley, where the Donner Laboratory was visited and where the research activities were demonstrated.

In the early evening, a reception was held in the Champagne Room of the Mark Hopkins Hotel, the host being Varian Associates of Palo Alto. The Annual Banquet was later held in the Peacock Court. Following the introduction of members and wives at the speakers' table, Dr. Gilbert Fletcher, with appropriate ceremony, presented the Janeway Medal to Dr. A. N. Arneson for his outstanding achievements. Members and guests were well entertained by a talented group of Hawaiian dancers and singers and also participated in dancing during the evening.

The final and fourth scientific session under the chairmanship of Dr. Grant Beckstrand included presentation of papers on a treatment system utilizing gamma-ray spectrometry; Co<sup>60</sup> radiography; transverse planigraphy and coordinated techniques; histology, natural history and results of treatment of salivary gland tumors; tumors of the central nervous system with surgery followed by irradiation or irradiation alone; and intracranial ependymomas —a study of survival with surgery and radiation therapy. The second half of the last scientific session was a symposium on the "Management and End Results in the Treatment of Metastatic Cervical Nodes" moderated by Dr. William S. MacComb. Different anatomic sites of the primary source of the metastatic nodes and the variations in the management were discussed by Dr. Robert A. Mustard, dealing with the oral cavity; Dr. Richard H. Jesse with the oropharynx; Dr. Lewis W. Guiss with the hypopharynx; and Dr. John V. Blady with the larynx. Many questions were asked of the Panel during the Discussion Period.

The Forty-fifth Annual Meeting of the American Radium Society proved to be unusually successful by its large attendance, by the high quality of its scientific program, and by the attractive social events in the charming and beautiful city of San Francisco. The members and guests of the Society owe a debt of gratitude to Dr. Jerome M. Vaeth, the members of his Committee on Arrangements and the many friends in the neighboring communities for their efforts.

HARRY HAUSER, M.D.



IRA I. KAPLAN, M.D. 1887-1963

"The path of duty was the way to glory. He that ever following her commands, On with toil of heart, knees, and hands Through the long gorge to the far light has won His path upward, and prevailed."

AGREAT pioneer in Radiology, Dr. Ira I. Kaplan, died on March 15, 1963, at the age of 76.

Dr. Kaplan was born on October 11, 1887, in New York City, where he received his preliminary education and Medical Degree in 1914 from the College of Physicians and Surgeons. After an internship at Mt. Sinai Hospital, he went to Europe to study in Germany with Holfelder, and then to the Curie Institute with Béclère. Upon his return to his native city, he was appointed assistant in Radiation Therapy at Bellevue Hospital. In 1925, when the Department was separated from Diagnostic Radiology, he was appointed its first Director. He served in that capacity uninterruptedly for 27 years until his retirement in 1952, because of statutory age limit.

In 1929, Dr. Kaplan was appointed Director of the Division of Cancer of the New York City Department of Hospitals, which post, along with Director of the New York City Cancer Institute, he held until 1940. He was Consultant to the Lenox Hill Hospital, the Beth David, French, Jewish Memorial, Beth-El and Southside Hospitals. At the New York University School of Medicine, he was first assigned to the Department of Surgery as Clinical Professor, and subsequently in Radiology as Clinical Professor.

He held Fellowship in the New York Academy of Medicine, the American College of Radiology; Membership in the American Roentgen Ray Society, American Radium Society, Radiological Society of North America, New York Roentgen Society, American Society for Cancer Research, American Cancer Society; and Honorary Membership in the Radiological Society of Panama.

Dr. Kaplan was the author of three textbooks which reflected his vast experience garnered at Bellevue Hospital. For 16 years, beginning in 1932, he was Editor of the Therapeutic Section of the Year Book of Radiology; and in 1939, co-author of an X-ray Therapy Atlas.

In 1937, he was awarded the Gold Medal for Scientific Achievement by the Phi Lambda Kappa Medical Fraternity.

Dr. Kaplan is survived by his wife, the former Ella Rubin, 2 children, and 6 grandchildren.

The career of Dr. Kaplan was intimately associated with Bellevue Hospital. Starting in one room, with but one old x-ray machine and without radium, he slowly won the support and admiration of his colleagues. By 1932, Bellevue Hospital possessed as much as 8 grams of radium, 5 of which were in a radium pack. The total gave Bellevue Hospital the distinction of possessing one of the largest amounts of radium for therapeutic purposes. The activities of the Service expanded rapidly under his judicious guidance, becoming a center of clinical teaching.

As the department progressed, new methods of therapy were developed, among which may be mentioned the Kaplan colpostat, small dose irradiation for the treatment of sterility and amenorrhea and other notable contributions. Dr. Kaplan's greatest joy, however, came from teaching medical students, residents and visitors. In this area he won acclaim by his stimulating enthusiastic, and encouraging approach to the new science. He was patient, tolerant, kindly, humble and always deeply pious. He leaves a great heritage to the hundreds of young men and women who trained with him and who now occupy positions of respect throughout the country.

"Whoever is open, loyal, true; of humane and affable demeanor; honorable himself, and in his judgment of others faithful to his word as to law, and faithful alike to God and man—such a man is a true gentleman"—such a man was Dr. Ira I. Kaplan.

SIDNEY RUBENFELD, M.D.

## **NEWS ITEMS**

## AMERICAN RADIUM SOCIETY ELECTS NEW OFFICERS

At the Forty-fifth Annual Meeting of the American Radium Society held at the Mark Hopkins Hotel, San Francisco, California, April 1–4, 1963, the following officers were elected: President, Charles G. Stetson, Tenafly, N. J.; President-Elect, Joseph H. Farrow, New York, N. Y.; 1st Vice-President, Juan A. del Regato, Colorado Springs, Colo.; 2nd Vice-President, John L. Pool, New York, N. Y.; Secretary, Justin J. Stein, Los Angeles, Calif.; and Treasurer, Milton Friedman, New York, N. Y.

The Forty-sixth Annual Meeting of the Society will be held at the Greenbrier Hotel, White Sulphur Springs, West Virginia, April 13–16, 1964.

## REFRESHER COURSE IN DIAGNOSTIC ROENTGENOLOGY

The fifth annual refresher course in Diagnostic Roentgenology will be held June 17–21, 1963 by the Radiology Department of the University of Cincinnati College of Medicine under the direction of Dr. Benjamin Felson, Professor and Head of the Department.

In addition to lectures and demonstrations, the course will include teaching methods employing audience participation.

Further information may be obtained by writing to Dr. Jerome F. Wiot, Department of Radiology, Cincinnati General Hospital, Cincinnati 29, Ohio. The course is open to radiologists and radiology residents.

## INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

The International Atomic Energy Agency, Vienna, Austria, organized 9 advanced training courses for scientists from the Member States in different parts of the world

The training courses scheduled for 1963 are:

Regional Training Course on the Applications of Radioisotopes in Medicine, Buenos Aires, Argentina, August 12–December 2, 1963.

Regional Training Course on the Maintenance and Repair of Nuclear Electronic Equipment, Colombo, Ceylon, November, 1963–April, 1964.

Advanced International Training Course on the Physics of Radiotherapy, London, United Kingdom, September 2, 1963– January 31, 1964.

International Training Course on the Use of Radiation and Isotopes in Entomology (together with FAO), Gainesville, Florida, USA, October 7–November 30, 1963.

International Training Course on Nuclear Science for High School Teachers, Nahal Soreq, Israel, July 28–September 5, 1963.

Regional Training Course on the Application of Radioactive Isotopes in Soil-Plant Relations, Ankara, Turkey, October 1-November 25, 1963.

Bio-Assay of Radionuclides, Seibersdorf, Austria, November 4, 1963–December 2, 1963.

International Seminar on Atomic Energy for Atomic Energy Administrators, Vienna, Austria, September 30–October 4, 1963. Regional Training Course on the Use of Research Reactors, India (subject to confirmation).

The program, of courses, is a part of the Agency's over-all training program which includes the award of some 400 fellowships for study abroad, several research grants, the interchange of professors and lecturers, and on-the-spot training with the help of its two mobile radioisotope laboratories.



## UNITED STATES ATOMIC ENERGY COMMISSION

## 1962 ANNUAL REPORT

Annual Report to Congress of the Atomic Energy Commission for 1962. Pp. 598, with numerous illustrations and 16 appendices. United States Government Printing Office, Washington, D.C., January, 1963.

The 1962 Annual Report of the United States Atomic Energy Commission, as required by the Atomic Energy Act of 1954, was submitted to Congress on January 30, 1963 by Dr. Glenn T. Seaborg, Nobel Laureate, *Chairman*, and Leland J. Haworth, John G. Palfrey, James T. Ramey and Robert E. Wilson, members of the Commission.

This Report has five main parts and 16 appendices. The first part briefly summarizes some of the Commission's more important actions and activities directed toward encouraging and maintaining a strong industrial and scientific participation in the Nation's atomic energy program.

Part Two concerns the joint effort of private industry and the Government to achieve competitive nuclear power, as well as the use of nuclear energy for space explorations and in remote locations.

In Part Three, the three major areas of activity related to the Commission's national defense mission are summarized. The activities of management of radioactive wastes are also included in this section because of their close relationship to the nuclear materials production program. In connection with the Military Applications section, Appendix 15—Environmental Contamination from Nuclear Explosives—is of particular interest to radiologists, since it concerns fallout data obtained from recent nuclear detonations.

Part Four is a general summary of Commission activities, ranging from the development of peaceful uses for nuclear explosives to the

program for dissemination of the technical information to industry and science.

Under Part Five, the Annual Report covers the Commission's program for licensing and regulating the use of nuclear materials and facilities. This section shows how the Commission is working with the individual states so that they can take a greater role in regulating the atom and its uses. It also shows how an effort is made to moderate, insofar as practicable, the more stringent regulations and policies in providing for easier industrial development while, at the same time, assuring continued maintenance of the controls necessary for public safety.

The growing interest in the use of strontium 90 and cesium 137 for isotopic power, process radiation, and medical teletherapy resulted in a significant over-all increase in the production and sales of radioisotopes. During the first 11 months of 1962, a total of 515,637 curies had been shipped from Oak Ridge National Laboratory as compared to 438,205 curies for a similar period in 1961, and 191,122 curies in 1960. As of November 30, 1962 the Oak Ridge National Laboratory had distributed a total of 2,080,864 curies in 169,052 shipments during the 16 year history of the radioisotope distribution program.

Great progress has also been made in the field of dosimetry. The range of the Fricke dosimeter has been extended from 40,000 rads to beyond a million rads, and a new high level dose dosimeter—the Silicon Solar Cell dosimeter—has been developed. Furthermore, work has been initiated on a completely new dosimetry system utilizing the effects of radiation on organic-metallic bonding in chemical systems.

As stated in the Preface of the Report: The year 1962 was one in which the Nation's nuclear energy program continued to move forward on an ever-broadening front.



### **BOOK REVIEWS**

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

A Text-Book of X-Ray Diagnosis by British Authors. In four volumes. Third Edition. Edited by S. Cochrane Shanks, C.B.E., M.D., F.R.C.P., F.F.R., Consultant Radiologist, University College Hospital, London, and Peter Kerley, C.V.O., C.B.E., M.D., F.R.C.P., F.F.R., D.M.R.E., Director, X-Ray Department, Westminster Hospital and The National Heart Hospital, London, Late Director of the X-Ray Department of the Royal Chest Hospital, London. Volume II. Pp. xiv + 991, with 819 illustrations. Cloth. Price \$27.00, W. B. Saunders Company, Philadelphia and London, 1962.

In the Webster Dictionary a classic is called a work of the highest class and acknowledged excellence. Such qualifications undoubtedly apply to Shanks and Kerley's textbook. It is, therefore, permissible to try and find some faults in it, since no human work can be expected to achieve absolute perfection.

This "chest" volume concludes the third edition of the four volumes, while its first volume (1957) is almost ready for a revision. Indeed, the authors are at work preparing a fourth edition. Although belatedly published, this "chest" volume still contains mostly positive reproductions, except for several angiocardiograms and for a very few other illustrations.

The volume has admittedly been aimed (also) at readers in "developing" countries. This may be why extensive space has been allotted to tuberculosis, while (primary) "Tumours of the Lungs" and "Secondary Malignant Disease in the Thorax" were given comparatively fewer pages.

Laudable attempts have been made to bring the volume up to date. It contains "new" sections on such items as coronary arteriography and Pneumocystis Carinii pneumonia; however, many investigators in this country would be hard pressed to accept at face value the opinion that cineangiocardiographic studies are in their infancy.

Some of these shortcomings become understandable when examining the bibliography appended to the volume. It contains references from the universal literature, but the textbooks consulted have all been in the English language,

including a translation from Zdansky. Additional information from sources other than those in the English language, in particular Werner Teschendorf's splendid opus, might have been used to advantage.

Admittedly, all these are merely "cosmetic" faults. A reviewer shows his true opinion of a book when he is faced with the decision of "eating (or not eating) the pudding." I had loaned my review copy of Shanks and Kerley's "chest" volume to a younger colleague who was studying for the examination of the American Board of Radiology. For such study this book is a most desirable asset. Indeed, the colleague passed his examination, but (said he) lost the book on the return trip. Thereupon I went to the bookstore and bought myself another copy of the same.

E. R. N. Grigg, M.D.

Synopsis of Roentgen Signs. By Isadore Meschan, M.A., M.D., Professor and Director of the Department of Radiology at the Bowman Gray School of Medicine of Wake Forest College, Winston-Salem, North Carolina; formerly, Professor and Head of the Department of Radiology at the University of Arkansas School of Medicine, Little Rock, Arkansas; with the assistance of R. M. F. Ferrer-Meschan, M.B., B.S., M.D., Melbourne, Australia. Cloth. Price, \$11.00. Pp. 436, with 465 illustrations. W. B. Saunders Company, West Washington Square, Philadelphia 5, Pa., 1962.

One of the difficulties experienced by the beginner in radiology is the search for a text which permits a quickly established basis for future reference. In this book the author has admirably accomplished this goal.

Using his experience as an author and teacher, Dr. Meschan has in a concise manner compiled a "Synopsis of Roentgen Signs."

The book is liberally illustrated with 465 figures including film reproductions and line drawings. Subdivided into 29 chapters, the subject matter is presented in brief outline form, covering the radiologic aspects of diseases and their clinical course, classification, and pathologic features.

The first chapters deal with fundamentals of technique, radiation protection, general terminology and concepts of radiology. These are followed by 9 chapters on the skeletal system including 1 on the basic concepts of bone formation. The next 8 chapters are devoted to the chest and its contents. The remaining 7 chapters encompass the abdomen and its contents including the genitourinary system.

Although the stated purpose of this text is to supply the medical student with a "Synopsis of Roentgen Signs," the outline form of presentation will prove of benefit to those more advanced in the field of radiology as a ready reference and an aid to rapid review.

Forrest Arnoldi, M.D.

#### **BOOKS RECEIVED**

Radioisotope Renography: A Kidney Function Test Performed with Radioisotope-Labeled Agents. By Chester C. Winter, M.D., F.A.C.S., Professor of Surgery and Director, Division of Urology, Ohio State University College of Medicine, University and Children's Hospitals, Columbus, Ohio; Consultant in Urology, Veterans Administration Hospital, Dayton, Ohio, and Wright-Patterson Air Force Base Hospital, Fairborn, Ohio. Cloth. Pp. 184, with many illustrations. Price, \$9.00. The Williams & Wilkins Company, Baltimore 2, Md., 1963.

La Pneumopelvigraphie: Technique D'Examen Gynécologique. By Claude Lagarde, Professor de Radiologie des Écoles de Médecine Navale, Radiologiste de la Fondation Bergonié; in collaboration with A. Hugues, Assistant de Chirurgie de la Fondation Bergonié; J. Chauvergne, Assistant de Gynécologie de la Fondation Bergonié; and G. Laurens, Assistant de Radiologie des Hôpitaux de la Marine. Paper. Pp. 148, with many illustrations. Price, 25 NF. Masson & Cie, Éditeurs, 120 Boulevard Saint-Germain, Paris, France, 1962.

KLINISCHE PHYSIOLOGIE: AKTUELLE PROBLEME IN ÜBERSICHTEN. Band I. By Dr. W. A. Müller, Chefarzt der II. Inneren Abteilung des Robert-Bosch-Krankenhauses, Stuttgart. Paper. Pp. 392, with many illustrations. Georg Thieme Verlag, Herdweg 63, Stuttgart, Germany, 1963. In the U.S.A. and Canada, Intercontinental Medical Book Corporation, New York 16, N.Y.

INTERNISTISCHE RÖNTGENDIAGNOSTIK: IN KLINIK UND PRAXIS. By Priv.-Doz. Dr. med. Hans-Jürgen Sielaff, Oberarzt und Leiter der Röntgenabteilung an der Medizinischen Universitätsklinik Heidelberg, Germany. Cloth. Pp. 728, with many illustrations. Price, DM 163.-. Ferdinand Enke Verlag, Hasenbergsteige 3, 7 Stuttgart W., Germany, 1963.

CURRENT MEDICAL TERMINOLOGY 1963. Edited by

Burgess L. Gordon, M.D., with John H. Talbott, M.D., Director, Division of Scientific Publications. Paper. Pp. 345. Price, \$2.00. American Medical Association, Circulation and Records Department, 535 N. Dearborn St., Chicago 10, Ill., 1962.

Selected Topics in Radiation Dosimetry. Proceedings of the Symposium on Selected Topics in Radiation Dosimetry, Sponsored by The International Atomic Energy Agency, Vienna, 1960. Paper. Pp. 685, with many illustrations. Price, \$9.50. International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria. In U.S.A. and Canada, International Publications, Inc., 801 Third Ave., New York 22, N.Y.

DIE OPERIERTE SPEISERÖHRE: PATHOLOGIE, KLINIK UND RÖNTGENOLOGIE; KOMPLIKATIONEN UND BEHANDLUNG. By Dr. Med. Mario Rossetti, Oberarzt an der Chirurgischen Universitäts-Klinik, Basel, Switzerland. Cloth. Pp. 126, with 78 illustrations. Price, DM 39.-. Georg Thieme Verlag, Herdweg 63, Stuttgart, Germany, 1963. In the U.S.A. and Canada, Intercontinental Medical Book Corporation, New York 16, N.Y.

Annual Review of Nuclear Science. Volume 12. Edited by Emilio Segrè, University of California. Cloth. Pp. 634, with many figures. Price, \$8.50. Annual Reviews, Inc., 231 Grant Ave., Palo Alto, Calif., 1962.

Newnes Concise Encyclopaedia of Nuclear Energy. Advisory Editors are; D. E. Barnes, O.B.E., G.M., B.Sc., R. Batchelor, M.A., A. G. Maddock, M.A., Ph.D., D.I.C., J. A. Smedley, B.Sc., and Denis Taylor, M.Sc., Ph.D. Cloth. Pp. 886, with many illustrations. Price, 160s. George Newnes Limited, Tower House, Southampton St., London, W.C.2., England, 1962.

BIOLOGICAL EFFECTS OF IONIZING RADIATION AT THE MOLECULAR LEVEL. Proceedings of the Symposium on the Biological Effects of Ionizing Radiation at the Molecular Level Held by the International Atomic Energy Agency at Brno. Paper. Pp. 461, with many figures. Price, \$9.00. International Atomic Energy Agency, Vienna, 1962. Distributed by National Agency for International Publications, Inc., 801 Third Avenue, New York 22, N. Y.

Collagen. Proceedings of a Symposium sponsored by the Central Leather Research Institute, Council of Scientific and Industrial Research, Madras, India, 1960. Edited by N. Ramanathan. Cloth. Pp. 580, with many illustrations. Price, \$20.00. John Wiley & Sons, Inc., 440 Park Avenue South, New York 16, N. Y.

Galle und Verdauungskanal: Eine Röntgenologische Funktionsanalyse. By Priv.-Doz. Dr. J. Franzen, Oberarzt des Institutes für klinische Strahlenkunde der Johannes-Gutenberg-Universität, Mainz. Paper. Price, DM 19.80. Pp. 99, with 30 illustrations. Georg Thieme Verlag, Stuttgart, Germany. In the U.S.A. and Canada, Intercontinental Medical Book Corporation, New York 16, N. Y., 1962.

## ABSTRACTS OF RADIOLOGICAL LITERATURE

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### ROENTGEN DIAGNOSIS HEAD

Bull, J. W. D. Contribution of radiology to the study of intracranial aneurysms. *Brit. M. J.*, Dec. 29, 1962, 2, 1701–1708. (Address: Consultant Radiologist, St. George's Hospital and National Hospital for Nervous Diseases, Queen Square, London, England.)

This paper is based on 1,769 confirmed intracranial aneurysms collected by McKissock over an 11 year period, 95 per cent first seen after rupture. The author stresses the importance of confirming the diagnosis by angiography. Both carotid trees should be investigated, and if no aneurysm is found vertebral angiography should be carried out later. The site, size, shape and possible multiplicity of aneurysms can thus be demonstrated as well as associated subarachnoid, subdural or intracranial hemorrhages. Multiple aneurysms were found in 14 per cent of cases.

Six types of aneurysms are discussed.

- (1) Congenital or "berry" aneurysms, which form the vast majority, usually develop at sites of bifurcation on or near the circle of Willis. Aneurysms on the intracranial vertebrobasilar tree are much less common but when present most arise at the termination of the basilar artery or at the junction of the vertebral and posterior inferior cerebellar artery. Consequently if both carotid and one vertebral tree are negative it is well to investigate the other vertebral tree.
- (2) Atherosclerotic aneurysms are infrequent and seldom rupture. They are not related to points of arterial bifurcation. Often they press on cranial nerves and they may present as tumor masses. The internal carotid, the basilar and the vertebral arteries are almost exclusively involved.
- (3) Dissecting aneurysms are very rare and the author has not encountered such a case.
- (4) "Berry" aneurysms are quite often found in patients who also suffer from cerebral arteriovenous angiomas. Some are situated on the arteries feeding the angioma, but not all.
- (5) Bacterial infective aneurysms develop secondarily to infected emboli and probably all rupture. Their distal position should make one suspicious of their true nature. Syphilitic aneurysms are extremely rare and nearly always situated on the basilar artery.
- (6) Traumatic aneurysms are also extremely rare, and this series includes only one such lesion, secondary to a gun shot wound.

Large unruptured aneurysms may mimic tumors by pressing on cranial nerves, obstructing the ventricular system or even giving rise to epilepsy.—

Arthur E. Childe, M.D.

Bhagwati, S. N., and Vuckovich, D. M. Craniopharyngioma presenting with acute

blindness: a case report. A.M.A. Arch. Neurol., Jan., 1963, 8, 101–104. (From: Departments of Neurosurgery and Neurology, Children's Memorial Hospital, Chicago 14, Ill.)

The authors report the case of a 17 month old girl who became totally blind in the course of 10 days. Skull roentgenograms revealed a small flake of calcium in the suprasellar region and a combined pneumoencephalogram-ventriculogram showed a rounded mass about 1.25 cm. in diameter in the interpeduncular cistern indenting and elevating the third ventricle floor. There was no dilatation of the third and lateral ventricles. At operation a cystic craniopharyngioma was removed completely. It stretched the optic nerves and chiasm moderately. There was no evidence of hemorrhage. Three months later her vision had recovered sufficiently for her to pick up small objects from the floor.

Only 3 cases of rapid total blindness from a craniopharyngioma have been reported previously. The authors feel that there must be interference with the circulation of small opticochiasmatic nutrient vessels to explain the visual loss.—Arthur E. Childe, M.D.

Sweet, W. H., Aronow, S., and Brownell, G. L. External localization of intracranial lesions with radioactive isotopes. *Schweiz. med. Wchnschr.*, Dec., 1962, 92, 1545–1550. (From: Division of Applied Physics and the Neurosurgical Service, Massachusetts General Hospital, the Nuclear Engineering Department, Massachusetts Institute of Technology and Department of Surgery, Harvard University Medical School.)

Experience with positron emitting isotopes As<sup>74</sup> and Cu<sup>64</sup> is described. Generally, results using the arsenic preparation were superior. The principle involves the prompt deceleration of positrons by collision with electrons, replacing the mass of the two particles by equivalent energy in the form of a pair of gamma rays. These emerge from the reaction in opposite directions, and if either undergoes scattering en route from the source to the scintillation counters placed opposite each other on either side of the head, it is excluded from the final picture by coincidence detection electronics circuitry.

In biopsy specimens, meningiomas reveal the highest tumor brain ratio of any histologic type, with tremendous increased uptake immediately after the injection. Glioblastomas show lower ratios, but unlike meningiomas, abnormal findings often persist to the next day, enabling second day scans to reveal tumor hidden in the background of muscle on the first day. Astrocytomas and oligodendrogliomas yield lower ratios. Glioblastoma was correctly localized in 96 per cent of 186 cases, and 96 per cent

figures were also obtained with 112 meningiomas, both using arsenic. Thirteen of 14 abscesses were also verified. Posterior fossa lesions were not analyzed, but poorer results here were mentioned—use of a sagittal scan with marked head flexion seems to improve the results.

The authors note the somewhat complementary uses of the conventional localizing technique and the isotope studies, with generally better isotope results in peripheral lesions and more accuracy on conventional studies with relatively centrally situated lesions.—Joseph H. Allen, M.D.

### NECK AND CHEST

LOCKE, G. BRIAN. Rheumatoid lung. Clin. Radiol., Jan., 1963, 14, 43-53. (From: Department of Radiology, Manchester Royal Infirmary, Manchester, England.)

This paper presents an investigation of the abnormal chest roentgenogram in patients with rheumatoid disease. Arthritis of rheumatoid type is a generalized disease and many organs and tissues in addition to the joints are involved. It can now be diagnosed with considerable precision by the sheep cell agglutination test (S.C.A.T.), which probably represents a specific macroglobulin reaction to the necrobiotic rheumatoid nodule. This disease produces a significantly high proportion of abnormal pulmonary and pleural changes. The pulmonary shadowing is nonspecific. Granulomata or nodular lesions can exactly simulate primary or secondary lung tumors. Pleural effusions are relatively common.

For this study (a) 54 patients with positive S.C.A.T. were compared with (b) 54 of a control group with negative S.C.A.T. The control group consisted of cases of ankylosing spondylitis, disseminated lupus erythematosus, osteoarthritis, polyarteritis nodosa and gout. In group (a) the basal lung pattern was abnormal in 15 but normal in all of the (b) group. Pleural opacity was present in 12 of the (a), and in 3 of the (b) groups, but these 3 represent 2 cases of disseminated lupus erythematosus and 1 case of polyarteritis nodosa. Pulmonary nodules were present in 2 of the (a) group and in none of the negative S.C.A.T. group.

Roentgenologically, diffuse lung lesions constitute the most frequent abnormality. The vascular pattern is seen to extend more peripherally than usual, almost reaching the lateral chest wall. This appearance is caused by an exaggeration of the normal peripheral vascular pattern of the lungs, the vessels appearing denser and a little thicker than normal. A fine nodular, almost punctate, pattern is occasionally seen, usually mainly basal in distribution. Coarser changes producing a "honey-comb" appearance when present are most obvious at the bases. Occasionally progressive enlargement of the hilar

shadows is noted, apparently caused by enlargement of the main pulmonary arterial trunks. *Granulomata*, when present are uniformly dense, well-defined nodules. These may be single or multiple, varying in size. They may cavitate and may fibrose and shrink. Calcification occasionally occurs in these nodules. *Pleural effusions* in the form of small basal collections are common. These are often bilateral and remain the same size over months or years.

Clinically, respiratory symptoms are uncommon in these patients, even in those who have extensive roentgenologic changes. Auscultation usually reveals persistent basal moist sounds. Treatment with steroids does not usually influence the diffuse type of lesions or "honey-comb" lung, but the nodules and pleural effusions may resolve quite rapidly.— Samuel G. Henderson, M.D.

Long, WILLIAM E., and MABRY, EDWARD H. (Memphis, Tenn.) The radiology of bronchiolitis. *South M. J.*, Feb., 1963, 56, 145–151.

The authors believe that bronchiolitis is a real clinical entity and can be distinguished from other diseases of the lungs in infants if rigid diagnostic criteria are adhered to and if roentgenograms of the chest are properly interpreted. They define this condition as an acute clinical syndrome seen in early infancy characterized by a precipitous onset of dyspnea and toxicity during an otherwise mild upper respiratory infection.

The clinical course is described as a sudden development of a distressing cough, severe wheezing and dyspnea often producing cyanosis. Frothing at the mouth from pulmonary edema and total collapse occur with more severe air hunger. These symptoms do not respond to ordinary medication and recovery depends almost entirely upon symptomatic treatment and nursing care. Some authors recommend bronchoscopy with aspiration of mucus.

The etiology has not been proved conclusively it may be due to specific organisms or to an altered anatomic situation. The pathology and pathologic physiology are described in detail.

The roentgen findings are evaluated under three headings: (1) emphysema, (2) atelectasis and (3) pneumonia. Many of the roentgenograms of these infants appear almost "too" normal but there is evidence of hyperventilation, *i.e.*, the diaphragm is depressed, there is retrosternal radiolucency, and frequently bulging of the intercostal space.

Seven roentgenograms are reproduced illustrating the roentgen findings in this condition.— John H. Harris, M.D.

Bourassa, Martial G. The scimitar syndrome: report of two cases of anomalous venous return from a hypoplastic right lung to the inferior vena cava. *Canad. M. A. J.*,

Jan. 19, 1963, 88, 115–120. (Address: Montreal Institute of Cardiology, 5415 Boulevard de l'Assomption, Montreal 36, Quebec, Canada.)

The "scimitar syndrome" is the term applied to a complex malformation involving the right pulmonary veins, the right lung and the heart. The anomaly consists of total drainage of the right pulmonary veins into the inferior vena cava, variable degrees of hypogenesis of the right bronchial tree and pulmonary arteries, and secondary dextroposition of the heart. The heart is displaced to the right, but the cardiac chambers have a normal relationship to each other. Cardiac defects such as interatrial septal defects, interventricular septal defects and absence or anomalies of the right pulmonary artery occur frequently. Absence or hypoplasia of 1 or 2 of the right major bronchi is found, and atretic bronchi terminate in blind pouches or diverticula. The right pulmonary veins unite to form a long common channel which runs downward, pierces the diaphragm and empties into the inferior vena cava. On a routine roentgenogram of the chest, this can be seen as a dagger or scimitar-shaped vascular density parallel to the cardiac border and this is the origin of the term "scimitar syndrome."

On the routine roentgenogram of the chest, the findings, in addition to the almost pathognomonic appearance of the crescentic shadow of the right pulmonary vein, consist of decreased vascularity of the right lung, shift of the heart and mediastinum into the right hemithorax, and possible enlargement of the right atrium or ventricle. On the left the pulmonary conus is prominent with increased pulmonary vascular markings and a small aortic knob.

The extent of the anomalies present can only be determined by special diagnostic procedures including bronchography, cardiac catheterization and angiocardiography.

Thirty-six cases of this condition have been reported. The author adds 2 more cases to the literature for a total of 38. The article contains excellent reproductions of the roentgenograms of these 2 cases.—Frank J. Rigos, M.D.

Prec, Klara J., Cassels, Donald E., Rabinowitz, Murray, and Moulder, Peter V. Cardiac failure and patency of the ductus arteriosus in early infancy. J. Pediat., Dec., 1962, 61, 843–854. (From: The Departments of Pediatrics, Surgery, and Medicine, University of Chicago Clinics, Chicago, Ill.)

Heart failure early in life is a relatively common complication in patent ductus arteriosus. According to some series in the literature, as many as 1 in 8 infants with patent ductus arteriosus develop heart failure and of this number about 15 per cent terminate fatally. The greater percentage of those who

developed heart failure have an excessively large pulmonary flow resulting from flow of blood from the aorta into the pulmonary artery via the ductus. In an occasional infant the main effect of a patent ductus is the early development of increased pulmonary artery resistance with a predominance of right heart failure, rather than left heart failure.

Two infants illustrating these two contrasting courses are presented. The work-up and detailed study consisted of clinical examination, dye dilution curves, cardiac catheterization, and angiocardiography. Both infants were treated surgically with successful operations and biopsies of the lungs were taken in each instance.

The first infant was referred because of a continuous Gibson type of cardiac murmur heard during a routine well-baby visit. This was a first born female infant and pregnancy and delivery were uneventual. On physical examination, the anterior fontanel was open and pulsating vigorously with the quality of a collapsing peripheral pulse. This striking finding disappeared immediately after operation for correction of the patent ductus arteriosus.

The second infant was a female and pregnancy was complicated by maternal rubella during the second month of pregnancy; the infant was delivered at 41 weeks by cesarean section because of evidence of fetal distress. She had microphthalmia with bilateral cataracts. She had parchment-like skin with long nails and other signs suggesting placental insufficiency or dysmaturity. On physical examination a cardiac murmur was first heard at 2 weeks of age. This was a Grade II harsh systolic murmur heard best at the second and third intercostal spaces close to the left sternal border. This infant was operated on successfully.

The fundamental difference between the 2 infants is expressed by the histologic differences found in the small vessels of the lungs taken at biopsy during the surgical procedures. The first infant's lungs showed dilated small muscular pulmonary arteries and pulmonary arterioles. The walls were thin with large lumen to wall ratios, and these resembled the pulmonary vessels seen in later life. The exact opposite was found in the second infant, whose vessels had the characteristic appearance of thick walled fetal vessels with well developed muscular media and a relatively narrow lumen. This appearance is believed to be seen in relatively high pulmonary resistance. Only a small systolic murmur could be heard in this infant along the left sternal border and there was only a mild shunt.

The appearances of the pulmonary blood vessels in the 2 infants were exactly opposite. Yet the ducti were equally large and presumably the resistance to blood flow presented by the ducti was similar. The factors which lead to the different responses illustrated by these 2 cases are not clear.

In an attempt to explain the different responses, the authors have commented on several possibilities.

The possibility that the time at which congestive failure occurs might determine whether pulmonary hypertension develops is considered. Heath reported that small pulmonary vessels were widely dilated in 2 infants with patent ductus arteriosus whom he studied. These were found to have decompensation at 2 days and 5 days of age respectively and this seems to negate the possibility of time as a factor. Harris has suggested in the literature that the retention of fetal type vessels in postnatal life is the result of some type of vasoconstriction. Rubella is considered an etiologic factor in congenital anomalies of the heart and great vessels, but frequency of accompanying pulmonary hypertenstion is not greater in those in whom there is a history of rubella. Anoxia accompanying postmaturity is considered another possible factor. This latter, in addition to placental dysfunction which was seen in the second case, may account for a retention of the thick walled fetal type vessels which were present in this infant.—Richard E. Kinzer, M.D.

COLAPINTO, RONALD F., THORFINNSON, P. CARMELLE, and HOLMES, R. BRIAN. Aortic insufficiency; a cine-radiologic assessment. J. Canad. A. Radiologists, Dec., 1962, 13, 112–116. (From: Toronto General Hospital, Toronto 2, Ontario, Canada.)

The detection of aortic insufficiency and the estimation of its severity have assumed great significance in recent years due to the introduction of surgical techniques for the correction of aortic and mitral valvular lesions. Physical examination has proved to be unreliable and the various procedures involving left ventricular catheterization have a significant morbidity.

A catheter with both end and side openings is passed via the femoral artery until its tip lies in the mid-ascending aorta. With the patient in the left anterior oblique position, 40–60 cc. of contrast medium is injected rapidly, using a pressure of 9 kg./cm². The cineradiologic study is recorded at 30–60 frames/sec.

Aortic insufficiency is classified as one plus if a small amount of contrast material enters the left ventricle with each diastole but is cleared completely with each systole. Two plus regurgitation occurs when a larger amount of contrast medium refluxes and is not completely cleared from the ventricle with each systole. Three plus insufficiency occurs when increasing amounts of contrast material accumulate in the left ventricle with each cardiac cycle. In four plus regurgitation a large amount of contrast material completely outlines the left ventricle during the first diastole following injection.

A small amount of contrast material may reflux through a normal aortic valve if the catheter is endopening in type and its tip is just above the valve. This type of regurgitation can be differentiated from true aortic insufficiency because it occurs when the valve is open in systole and lasts only as long as the injection. The authors have avoided this by using a catheter with both side and end openings, and by placing the tip in the mid-ascending aorta.

Several factors influence the interpretation. During a long diastole associated with bradycardia or a ventricular premature beat the amount of aortic insufficiency appears to be greater than it really is. Tachycardia has the opposite effect since it shortens diastole. Heart failure with poor emptying causes an accumulation of contrast material within the ventricle even with slight aortic insufficiency. If any of these factors apply, the degree of insufficiency is upgraded or down-graded accordingly.

The authors compare their method with the reflux test using Evans blue dye and conclude that the radiologic method is much more reliable in assessing small but still significant degrees of insufficiency. Cineradiography is also capable of demonstrating slight degrees of insufficiency which cannot be seen on static films.—J. L. Williams, M.D.

Mustard, W. T., Trimble, A. W., and Trusler, G. A. Mediastinal vascular anomalies causing tracheal and esophageal compression and obstruction in childhood. *Canad. M. A.* J., Dec. 22, 1962, 87, 1301–1305. (From: Department of Surgery, Hospital for Sick Children, Toronto, Ontario, Canada.)

Of 22 cases of mediastinal vascular anomalies reported, 13 had double aortic arch; 3, right aortic arch and left ligamentum arteriosum; 3, anomalous innominate artery; I, an aberrant right subclavian artery; I, a right aortic arch with aberrant left subclavian artery and left ligamentum arteriosum; and I, anomalous left pulmonary artery producing emphysema of the right lung. No analysis of roentgenographic data was made, and tracheographic studies are not mentioned. Bronchoscopy was nearly always done and was often helpful in determining the nature of the tracheal compression, the compression of the area of tracheal constriction with the tip of the bronchoscope often obliterated corresponding pulses giving an exact diagnosis. Only one patient of the many encountered had an operation for aberrant right subclavian artery. This was a one month old infant with regurgitation and respiratory distress related to feeding, and a marked esophagraphic defect. Temporary relief was obtained from a division of the aberrant right subclavian artery. A recurrent difficulty in the late postoperative period was found to be reflux esophagitis and hiatus hernia.

Four deaths occurred in this series, I during intubation and 3 in the postoperative period, probably a result of persistent tracheal softening related to the original lesion.—Joseph H. Allen, M.D.

FONTAINE, R., WARTER, P., WEILL, F., and WEBER, J. L'ulcère de l'oesophage; étude radiologique à propos de 8 cas. (Esophageal

ulcer; radiologic study of 8 cases.) J. de radiol. d'électrol. et de méd. nucléaire, Nov., 1962, 43, 699-705. (From: Clinique chirurgicale A, Strasbourg, France.)

In an esophageal ulcer, besides the mucous membrane lesion, there is a mutilating sclerotic change of subjacent muscular coat. The pathogenesis is probably analogous to that of gastroduodenal peptic ulcer or perhaps more similar to that of postoperative peptic ulcer. Excluding the traumatic, chemical and endogenous (after burns) types, ulcers of the esophagus can be classified as primary and secondary.

The authors report 4 cases of each category with fine roentgenographic reproductions. Niche-like projections were demonstrated in all 8 cases reported. Associated roentgen signs of spasm, megaesophagus, hiatus hernia, stenosis due to esophagitis were demonstrated in one or another of these cases.

The only superiority of cineroentgenography is perhaps in the differential diagnosis of small diverticula of the esophagus.—Jirair N. Sarian, M.D.

#### ABDOMEN

Tristan, Theodore A. Prospectus of radiologic technics for gastroenterology. Am. J. Digest. Dis., Jan., 1963, 8, 33–53. (From: The Schools of Medicine, University of Pennsylvania, and Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia 4, Pa.)

The use of roentgen cinematography or cinefluorography is presently receiving considerable attention.

Functional evaluation of the alimentary canal, *i.e.*, evaluation of movements with respect to the passage of time has settled few controversies, due to the difficulty of correlating motion with pathologic entities, as opposed to correlating form with pathology. For example, the argument relating to the diagnosis of duodenal ulcer persists. One group insists that the ulcer crater must be demonstrated to permit the diagnosis. The other group makes the diagnosis on the bases of functional changes—irritability and spasm and/or abnormal peristalsis.

In televised fluoroscopy, the usual fluoroscopic screen is replaced by an image intensifier (synonyms: image convertor, image amplifier), the commonest and most practical form of pick-up device available today. The image may be viewed in daylight or subdued light by means of a television camera on a television monitor. It can be simultaneously recorded on motion picture film using the cinecamera.

The future of television fluoroscopy seems assured. Of significance are daylight television systems such as the Marconi and the Cinelix.

Recently, interest in the possibility of substituting magnetic tape recording for motion picture film and/or spot roentgenograms as a routine method of recording fluoroscopy has been stimulated by the

method for the routine examination of children at the University of Pittsburgh. This gives the operator the potential of immediate recall of fluoroscopy, reduced storage of roentgenograms and cinefluorograms and elimination of film processing.

Among the procedures having some potential are attempts at miniaturization of the image. Outstanding examples are the mirror optical rapid serial-ographic machines marketed in a variety of forms. The most practical film size is 4×4 inches. The film transfer rate can now be increased to 6 pictures per second. One can anticipate that splenoportography, intestinal arteriography, and perhaps routine gastrointestinal roentgenograms can be made in miniature with no loss of diagnostic potential but at a great saving in film cost.

Another method of miniaturization employs high speed polaroid transparency film to make "spot films" of the output phosphor of the image intensifier. Still another idea has been the use of either 70 mm. film or No. 120 amateur negative film to record the image formed on the output phosphor of the image intensifier.

A method of image enhancement is logEtronography, where additional films are exposed so that contrast is enhanced over a selected range of densities. It has chiefly been employed to enhance the contrast of images to provide a better quality of reproduction for publication.

Xero-radiography should be mentioned only to dismiss it. The complexity and instability of the system, the additional radiation required, and the poor quality for thick body parts as, for example, the abdomen make it useless for gastrointestinal studies.

Abnormalities of the vascular system supplying the alimentary canal have received much attention lately, investigations having been mostly performed by Swedish workers in radiology.

The possibility of segmentally studying a branch of the aorta while the patient is being operated on is an exciting one. The area of interest is directly injected with the opaque medium under operative television control. The findings are recorded using serial roentgenograms, motion pictures, or magnetic tape recording of the image. The margins of necrotic lesions may thus be defined and the tumor can be distinguished from the normal by alterations in vascular supply. Evaluation of the vascular supply to an organ at operation will be possible.

The diagnosis of arteriosclerotic vascular disease of the gastrointestinal tract and possible remedial surgery using venous or artificial grafts present a new challenge to the practicing gastroenterologist, surgeon, and radiologist.

The opacification of the liver by intravenously ininjected radioactive materials such as radioactive rose bengal or colloidal radioactive gold is well understood and is widely employed. The uptake of the material is displayed by a scintillation scanner either as a dot scan on paper or as a photographic dot scan.

Attempts to opacify the pancreas by absorptive

techniques or by employing other radioactive elements have been disappointing. The most promising method at present appears to be the use of selenomethionine which has been reported to be clinically feasible by Blau and Bender, now used on a limited basis. Arterial opacification of the pancreas; preoperative roentgenography of the pancreatic ductal tree; and indirect methods employing various combinations of pneumoperitoneum, retroperitoneal air placement, splenoportography, and transverse axial laminagraphy, are other methods available. These require expensive equipment, much time, a persevering physician, and a patient with endurance.—

Stephen N. Tager, M.D.

ARIEL, IRVING M. The site of upper gastrointestinal bleeding; detection by radioactive-tagged red blood cells. J.A.M.A., April 21, 1962, 180, 212–214. (Address: 139 East 36th Street, New York, N. Y.)

The author describes a rather ingenuous method of determining whether upper gastrointestinal bleeding is coming from the esophagus or from the stomach or duodenum. His method uses radioactive tagged red blood cells. He employs a tube having a double lumen with holes inferior to a balloon and other holes superior to the balloon. The balloon is passed into the stomach and inflated and drawn taut against the esophageal gastric junction. The inflated balloon acts as a seal and secretion or blood can be sucked out of the esophagus or out of the stomach, without allowing a mixture to occur.

The patient's blood is withdrawn immediately upon being hospitalized and is heparinized; radioactive chromium is mixed with the blood and given back to the patient intravenously. It is necessary that the test be performed while the patient is actively bleeding. Suction is applied to the outlets of both lumina of the tube placed in the esophagus. If bleeding is occurring from the esophagus, blood will be withdrawn from the esophageal portion of the tube and when counted it will contain a high degree of radioactivity. There may be blood in the stomach which has come down from the esophagus. This blood will not be radioactive since it was present in the stomach before the radioactive blood was injected intravenously.

The author points out that the technique has had a high degree of accuracy for him. One of his patients who had bleeding from the duodenum also had severe cirrhosis, and the test in this patient established the diagnosis of a duodenal ulcer even in the presence of cirrhosis with portal hypertension.—Richard E. Kinzer, M.D.

Charles, Rene N., Kelley, Maurice L., Jr., and Campeti, Frank. Primary duodenal tumors: a study of 31 cases. A.M.A. Arch. Int. Med., Jan., 1963, 111, 23–33.

(From: Departments of Medicine and Radiology of the University of Rochester School of Medicine and Dentistry, Rochester, N. Y.)

The records of all patients with a proved diagnosis of primary duodenal tumor seen at the University of Rochester Medical Center during the years 1950 through 1961 were reviewed. Only those patients in whom operation was performed and tissue obtained for histologic examination were included.

Twenty-one cases of primary benign tumors of the duodenum and 10 cases of primary malignant tumors of the duodenum were acceptable by these criteria. All instances of ampullary carcinoma, carcinoma of the pancreas, carcinoma of the stomach invading the duodenum, and other extraduodenal tumors were excluded.

The clinical data and roentgenographic, surgical, and pathologic findings are summarized in tabular form.

In the group of primary benign tumors upper gastrointestinal bleeding producing strongly guaiacpositive stools occurred in 8 patients but was related to the duodenal tumor in only 5. Filling defects suggesting polyp, adenoma, or other tumor were diagnosed by the radiologist in 17 of the 21 patients. In 1 case, a noninvasive carcinoid tumor 1×1 cm. was found at operation, instead of the suspected duodenal polyp. All but 2 of the benign tumors were located in the first portion of the duodenum. The exceptions were a patient in whom a cystic lesion containing fluid with a high amylase content was found in the wall of the second portion of the duodenum. Another patient was found to have lymphangioma of the second portion of the duodenum.

Ten patients had primary malignant tumors of the duodenum. Seven were men and 3 were women. Their ages ranged from 51 to 82 with a mean of 66.5 years. The symptoms experienced by these patients could, in most instances, be adequately explained by the duodenal malignancy as contrasted to the doubtful symptomatology produced in the patients with benign tumors. Weight loss was a prominent feature in 6 patients. Vomiting probably due to duodenal obstruction occurred in 5 and upper abdominal pain in 4. Four patients were jaundiced due to obstruction of the ampulla of Vater by the malignant growth. Bleeding manifested by occult blood in the stools was noted in 5 patients. One patient vomited coffee ground material. Anemia was the presenting feature in 2 patients. The radiologist was able to recognize a tumor or obstruction of the duodenum in 7 of the 9 patients in whom a barium examination of the upper gastrointestinal tract was performed. Six of the malignant tumors were located in the second portion and 4 in the third portion of the duodenum. No adenocarcinomas were found in the first portion of the duodenum.

The primary malignant tumors are usually observed clinically. Benign duodenal tumors are more often discovered (incidentally) at autopsy. A large variety of histologic types is encountered. The commoner varieties are adenomas, polyps, lipomas, myomas, and fibromas. These tumors as a rule are asymptomatic and therefore preoperative detection and identification may be quite difficult.

Primary carcinoma of the duodenum is an unusual lesion. The ratio of incidence of primary carcinoma of the duodenum compared with that of the stomach is said to be 1:100. Eight patients died within an average of 9.6 months after a positive diagnosis of carcinoma was made. Cinefluorographic studies of the duodenum were helpful in the evaluation of 2 patients.

Barium studies of the upper gastrointestinal tract detected a duodenal lesion in 24 of the 31 cases.— Stephen N. Tager, M.D.

Bernstein, James S., Groisser, Victor W., and Lawrence, Lewis R. Abnormal small-bowel x-ray patterns associated with active duodenal ulcer. *Am. J. Digest. Dis.*, Feb., 1963, 8, 174–190. (Address: 187 Hempstead Avenue, Rockville Center, Long Island, N. Y.)

Having noted that duodenal ulcer has not been included among the 40 or so conditions discussed in the literature with which an abnormal small bowel roentgenologic pattern may be associated, the authors proceeded to review and to document the association of active peptic ulcer and abnormal small bowel roentgenologic patterns, and attempted to elucidate the mechanism of these changes. Thirty-seven such cases were reviewed, with all initial gastrointestinal roentgen examinations having been performed with conventional U.S.P. barium. The usually accepted criteria for diagnosing an abnormal small bowel pattern, and for diagnosing peptic inflammatory disease of the stomach, duodenum, or jejunum adjacent to a gastro-enterostomy were invoked, with equivocal cases being excluded. There was a considerable range in the severity of change in the small bowel pattern, with the pattern being so disturbed in 4 patients that a diagnosis of intrinsic small bowel disease was seriously considered. No patient who had a gastric ulcer and an abnormal small bowel pattern on roentgenologic examination was encountered. Clinically, the authors were impressed by the regularity with which a classic ulcer syndrome appeared in the histories of these patients.

Following the initial gastrointestinal series when the patient was acutely symptomatic, and at which time the abnormal small bowel pattern was discovered, 25 of the patients were available for reexamination following medical or surgical therapy, when they were essentially symptom free. The reexamination was done with conventional U.S.P. barium, and in all but 2 of these, the small bowel roentgenologic pattern had reverted to normal. Thir-

teen patients with active peptic ulcer and abnormal small bowel patterns seen on conventional barium studies were restudied within 8 days with a non-flocculent (micropaque) barium mixture. In all 13 patients studied with micropaque, the appearance of the small bowel pattern was normal or only minimally altered, despite the presence of continuing symptoms in some of the patients.

In these cases the altered small bowel pattern did not appear to be related to malnutrition, blood in the intestine, deficiency or malabsorption states, or to altered intestinal motility. Neither did emotional stress appear to be the prime factor, although this admittedly was difficult to evaluate. The data accumulated in this study suggest that agglomeration is an important factor in the genesis of abnormal small bowel patterns in peptic ulcer patients, as micropaque corrected the abnormality in every instance. It is theorized that the stomach, and perhaps the intestine itself, produces excessive or qualitatively altered mucus, when under the stress of gastrointestinal peptic ulceration, particularly at times when the patient is symptomatic. The authors also suggest that the terms "deficiency pattern" and "disordered motor pattern," used in describing abnormal small bowel patterns, are too limited in scope to cover all possible etiologic mechanisms and that a new descriptive term is needed to fit a multiple-factor concept of cause.—Donald M. Monson, M.D.

Lumsden, K., Chaudhary, Nazir A., and Truelove, S. C. The irritable colon syndrome. *Clin. Radiol.*, Jan., 1963, 14, 54–63. (From: The Radcliffe Infirmary, Oxford, England.)

The "irritable colon syndrome" includes a variety of colonic functional disturbances, divided into two main clinical groups, (a) spastic colon, (b) chronic simple diarrhea. Etiologic factors listed by the authors include psychologic disturbances, an attack of dysentery, either amebic or bacillary, dietary habits (symptoms coming on after large, rich meals, but relatively symptom free with a plain and well-ordered diet), specific sensitivity to certain foods, such as milk, wheat or chocolate, and abuse of purgatives.

Pain is the outstanding symptom of *spastic colon*; this is most common over the descending and sigmoid portions, but it may occur over any part of the colon. It may be either continuous or intermittent, and it may be relieved by defecation. Constipation may alternate with short bursts of diarrhea, although the bowel movements are often normal. Mucus is often passed by rectum when constipation is present. In those patients with *chronic simple diarrhea* as the main symptom, the diarrhea may be intermittent or it may be continuous over many months or years.

In diagnosis, exclusion of major organic disease is essential. In the presence of anemia or a raised erythrocyte sedimentation rate organic disease should always be suspected. Sigmoidoscopy permits the exclusion of focal lesions, and can be used to rule out ulcerative colitis. A barium enema study is essential in making the diagnosis of irritable colon syndrome. This assists in the exclusion of organic disease, and it may give positive evidence to support the diagnosis. To obtain reliable positive evidence purgatives should not be given within 48 hours of the time of examination, and a cleansing enema of plain water should be administered on the preceding evening. A plain barium enema suspension free from agents to stimulate the colon should be used. With such technique a reduced size of lumen and increased number of haustral markings, and, in more severe cases, actual segmental spasms furnish good evidence of the irritable colon syndrome. There is no constant postevacuation pattern. Evacuation may be almost complete, leaving only a trace of barium coating the mucosa. In others, almost all of the barium may remain. In those patients who secrete an excessive amount of mucus there is a deficiency of the normal mucosal pattern, due to the failure of the barium to adhere to the mucosa when much mucus is present.

In correlating the roentgenologic findings with a colonic motility study (the technique of which is described by the authors), under resting conditions patients with spastic colon have evidence of excessive colonic motility on their pressure tracings, while patients with chronic diarrhea have less motor activity than normal persons; but on barium enema study these two groups of patients present appearances which are closely similar, usually with evidence of "irritability." After an injection of prostigmine patients with the irritable colon syndrome usually show excessive motor activity, regardless of whether their symptoms are those of spastic colon or chronic diarrhea, and regardless of whether they are having symptoms or are symptom free.

If there is the slightest doubt about the diagnosis the barium enema examination should be repeated with full-fledged preparation and the use of a double contrast method.—Samuel G. Henderson, M.D.

GLAY, A. Toxic dilatation of the colon in the course of ulcerative colitis. Canad. M. A. J., Feb. 2, 1963, 88, 234–239. (From: Department of Radiology, St. Mary's Hospital, and Gastroenterological Research Laboratory, McGill University, Montreal, Quebec, Canada.)

Toxic dilatation of the colon occurs as a complication of ulcerative colitis in 2 to 8 per cent of patients, usually during an acute stage of the disease. Mortality attributed to this complication has been reported to be as high as 18 to 35 per cent. Perforation of the colon is most frequently observed.

Clinically, toxic dilatation of the colon is heralded by crampy abdominal pain, fever, hypotension, distention of the abdomen and decreased to absent bowel sounds.

Roentgenographically, the diagnosis can be confirmed by plain film examination of the abdomen, including erect and decubitus roentgenograms. Barium enema study of the colon, when toxic dilatation is suspected is strongly contraindicated. In addition to either segmental or diffuse distention of the colon, air-filled ulcers and fistulae, lack of redundancy of the colon, and the presence of pseudopolyps in the colonic lumen are often found to constitute signs of the underlying disease.

The etiology of toxic dilatation of the colon remains obscure; however, there is believed to be a relationship between the administration of anticholinergic drugs and the onset of the toxic dilatation.

Once the diagnosis has been established, conservative therapy may be instituted.—John H. Harris, M.D.

FARIBAULT, C., BAILLARGEON, J., and DUFRESNE, M. Smaller rectum: non-specific early sign of lesion. *J. Canad. A. Radiologists*, Dec., 1962, 13, 126–130. (From: Notre Dame Hospital, Montreal, Quebec, Canada.)

The authors measured the maximum width of the filled lower rectum on 156 barium enema studies. The mean width of all cases was 7.1 cm. In 23 patients the rectum was smaller than 6 cm. in diameter. Fifteen of these patients with a narrow rectum had some type of abnormality such as ulcerative colitis, polyps, carcinoma, fissure and fistula. The narrow rectum was nonspecific and apparently normal in 8 cases.

In 43 cases of ulcerative colitis the mean width of the lower rectum was 5.2 cm., and in 29 of the patients the width of the rectal ampulla was less than 6 cm. Patients with carcinoma of the rectum and rectal polyps also tended to have a narrow ampulla.

The authors conclude that it is important to measure the diameter of all rectal ampullae in order to help detect early cases of colitis, proctitis, fissure, fistula, polyp and carcinoma.—J. L. Williams, M.D.

GLENN, JOHN C., JR., and O'BRIEN, PAUL S. Ipodate: a new medium for cholecystography and cholangiography. South. M. J., Feb., 1963, 56, 167–169. (From: Department of Radiology, Mercy Hospital, Charlotte, N. C.)

A new oral cholecystographic contrast medium, ipodate (Oragrafin—Squibb), was given to 102 patients for biliary tract study. Some patients were prepared in usual "12 hour" examinations and others in "2 hour examination;" in most patients good visualization of the gallbladder and fair visualization of the bile ducts was obtained.

In the authors' experience ipodate (Oragrafin) was found to be useful because of its safety, high yield of diagnostic cholangiograms and rapid opacification of gallbladder and bile ducts.

In many instances the cholecystographic examination can be completed within 2 hours after oral administration of the granular ipodate.—John H. Harris, M.D.

#### RADIATION THERAPY

THOMAS, CHARLES I., STORAASLI, JOHN P., and FRIEDELL, HYMER L. Lenticular changes associated with beta radiation of the eye and their significance. *Radiology*, Oct., 1962, 79, 588–597. (Address: 2065 Adelbert Road, Cleveland 6, Ohio.)

The use of a Sr<sup>90</sup> ophthalmic applicator has become fairly commonplace, and reports concerning its physical characteristics, response to irradiation, and dosage schedules are now available. Much has been written concerning the complications observed following beta irradiation of the eye, such as scleral atrophy, conjunctival scarring, and telangiectasia. The one factor not completely evaluated is damage occurring in the lens.

Changes in the lens follow a well known pattern after exposure to radiation. In general, 500 r is considered potentially dangerous to the human lens, with onset of cataract formation after 2 to 10 years, or possibly as long as 15 years. The equatorial edge of the eye is the most sensitive to radiation, and lies about 3 mm. deep, where it will receive about 10 per cent of the surface dose. Cells in the equatorial region that are damaged are later seen more centrally, where they have migrated or have been pushed. As a rule, damage is proportional to dosage.

The authors report on their experience with 186 patients receiving treatment to the globe. Of 186 patients surveyed, 12 were lost to follow-up and in 59 corneal opacifications prevented examination of the lens. The remaining 115 had detailed ophthalmologic examination, and the presence or absence of lenticular opacifications was noted. The patients surveyed had received treatment for vascular keratitis, postoperative vascularization, pterygium, tumors, and epithelization of the anterior chamber. Surface dosage ranged from 1,800 rep to 25,000 rep. In the 3,600 to 7,200 rep dose range, 20 per cent of the patients had opacities 8 years later, while above 12,000 rep, 73 per cent had changes. In general, when the surface dose of beta radiation reaches 10,000 rep, lenticular opacities will occur in 50 per cent. Clinically most of the changes are not significant, with the worst vision noted in the authors' series being 20/40, and apparently remaining stationary. It is emphasized that while sequelae may occur following use of the beta applicator, the clinical benefit usually far outweighs the possible damage.—James C. Moore, M.D.

RAVENTOS, A., HORN, ROBERT C., Jr., and RAVDIN, I. S. Carcinoma of the thyroid gland in youth: a second look ten years later. J. Clin. Endocrinol. & Metabol., Sept., 1962, 22, 886–891. (From: The Department of Radiology, Laboratory of Surgical Pathology, Department of Surgery, Endocrine Section of the Medical Clinic, and Penn Mutual Life Insurance Company Foundation for the Study of Neoplastic Disease, Hospital of the University of Pennsylvania, Philadelphia, Pa.)

The authors present a 10 year follow-up of a group of thyroid cancer patients, all of whom were 25 years of age or younger, at the time the diagnosis was made. The original study was published in the *Journal of Clinical Endocrinology* in November, 1951. There were 22 patients in the group at the time of the initial report, 4 of whom represented 5 year survivals, and 1 who had survived 16 years.

To date, only I patient has died of thyroid carcinoma, although 2 have roentgenographic evidence of slowly progressing pulmonary metastases. One patient has died of an unrelated rectal carcinoma, and the remaining 18 are alive without evidence of disease. Of the 2 dead patients, both had "solid" tumors, as opposed to the papillary follicular tumors of the remaining patients; however, in I the tumor was compatible with long survival, the patient having died of the unrelated rectal carcinoma.

Treatment of the series included 4 partial lobectomies, 13 total lobectomies, 3 total thyroidectomies and 1 neck dissection with roentgen therapy. Four had therapeutic doses of I<sup>131</sup>. The only patient who actually died of thyroid cancer had no surgical treatment other than biopsy. This should not suggest that the results have been due to haphazard therapeutic modalities, since careful evaluation and selection of the individual were made prior to final choice of treatment.

In the report of 1951 it was stated that the authors had no knowledge of previous radiation therapy for thymic enlargement in this young group of thyroid cancer patients, but no particular effort was made at that time to elicit this information. They now state that after specific investigations were made at least 50 per cent of the patients in the series did receive radiation to the thymus in their infancy. The authors present evidence that due to the difficulty in obtaining an accurate history of previous thymic irradiation, its incidence in thyroid cancer patients may actually be higher, not only in this series but others as well.

They feel that the data thus far accumulated do not prove that irradiation causes thyroid cancer in man or that children are more likely to develop it than adults, although a history of previous therapeutic irradiation appears to exist in the majority of children. Sufficient effort must be made to elicit it.—

Harry J. Batts, M.D.

ABBATUCCI, J. S., and ROBILLARD, J. Valeur de la mammographie et intérêt de son association avec le forage-biopsie. (Value of mammography and study of its association with drill-biopsy.) J. de radiol., d'électrol. et de méd. nucléaire, Aug.—Sept., 1962, 43, 478—484. (From: Clinique Chirurgicale A, Strasbourg, France.)

Mammography and drill-biopsy together are very useful in investigation of breast lesions. In 21 of 26 patients the results were identical with the two methods. In the remaining 5 cases, mammography used alone would have resulted in a diagnostic error in 4 patients, whereas drill-biopsy alone would not have afforded the proper conclusion in 3 instances. Simultaneous uses of both procedures has allowed only 1 error in the 26 cases.—*Charles M. Nice*, Jr., M.D.

Magalotti, Marion F., Hummon, Irvin F., Garces, Rafael M., and Naumoff, N. S. R. Radiation therapy through cooled skin. *Radiology*, Sept., 1962, 79, 435–438. (From: Radiation Center, Cook County Hospital, Chicago 12, Ill.)

In an attempt to develop a technique to decrease undesirable skin reactions, the authors studied the effect of radiation therapy through cooled skin. A hollow aluminum sandwich was made with two tubular connectors to permit circulation of cold water at a temperature of °C. The surface of the aluminum sandwich had a temperature of 5°C. A duplicate device kept filled with water at room temperature was used as a control. The cooling pad measured 12×17×1.5 cm. over all, with a wall thickness of 2 mm. The technical factors were 200 kv., skin target distance 50 cm., half value layer 1.25 mm. Cu. The patients received a conventional course of therapy, 150 to 200 r (air) to two ports daily, with a total of 2,400 to 2,800 r (air) to each port in 5 to 6 weeks.

The study was done on 100 consecutive women with pelvic tumors, all treated through four ports, two anterior and two posterior, measuring from 10 ×15 to 12×15 cm. The left anterior and the right posterior ports were treated with the control device. The right anterior and the left posterior ports were treated with the cooling device.

There was visible difference between the cool and control ports in 60 per cent of the patients in the acute stage of the radiodermatitis. Healing of the skin was faster in the cooled ports and late changes were considerably less than on the control side. The decreased changes due to cooling at the time of irradiation can be explained by several hypotheses: (a) decreased metabolic and/or respiratory rate causing decreased radiation response; (b) decreased oxygen tension secondary to vasoconstriction; and (c) pressure causing ischemia. These concepts assume that

the degree of tissue radiosensitivity is proportional to the rate of tissue metabolism.—Arno W. Sommer, M.D.

#### RADIOISOTOPES

Benassi, E., Ollino, P., Sannazzari, G. L., and Torretta, A. I "nodi caldi tiroidei" studiati con la scintillografia in tempi successivi. (The "hot nodes of the thyroid" studied by a scintigraphic system at successive intervals of time.) *Radiol. med.*, July, 1962, 48, 625–634. (Address: Dr. E. Benassi, Via Genova 3, Torino, Italy.)

The authors report the results of experimental and clinical studies with the scintigraphic system devised by Benassi and Ollino. With this scintillation detector, simultaneous scintigrams of the thyroid, a roentgenogram of the area explored, and a recording of the variations in the degree of uptake of the radioiodine by the thyroid can be obtained. This is accomplished by using a rate meter which functions in parallel with the scintigraphic equipment.

With this system it is possible to demonstrate very small hot spots which normally would be overlooked or not fully evaluated.

The authors suggest that whenever a hot spot is suspected, the scintigraphic examinations should be performed 2, 4, and 24 hours after the administration of the radioiodine.—A. F. Govoni, M.D.

Wallach, Stanley, and Jones, H. Leonard. Oral and intravenous I<sup>131</sup>-triolein tests in the assessment of disturbed triglyceride metabolism. Am. J. M. Sc., Nov., 1962, 244, 612–621. (From: The Departments of Medicine, U. S. Naval Hospital, Chelsea, Mass., and The State University of New York, Downstate Medical Center, Brooklyn, N. Y.)

It is believed that lipid disturbance in many diseases associated with hypercholesterolemia (such as coronary atherosclerosis, nephrotic syndrome, xanthelasma, hypothyroidism, etc.) is complex and may involve a triglyceride metabolism. The study was undertaken to investigate this hypothesis and to determine the suitability of a recently developed radioactive triglyceride preparation for intravenous use. The intravenous I<sup>131</sup> triolein yielded more consistent results than did the oral I<sup>131</sup> triolein preparation.

The data showed a persistent elevation of plasma radioactive lipid concentration but normal fractional turnover of triglycerides in the patient group. This suggests both an increase in metabolic production and a degradation of triglycerides.—Bernard Loitman, M.D.

Oddie, T. H., Melby, J. C., and Scroggs, J. E. Statistical analyses of radioiodine and pro-

tein-bound iodine test results on Arkansas thyroid patients. J. Clin. Endocrinol. & Metabol., Nov., 1962, 22, 1138–1147. (From: University of Arkansas Medical Center, Little Rock, Ark., and University of Arkansas, Fayetteville, Ark.)

Results of tests of thyroid function in Arkansas patients have been analyzed with the aid of a digital computer. Included in the series were 467 patients unaffected by prior medication. The tests included early clearance rate of I131, 24 hour accumulation of I<sup>131</sup> and protein-bound iodine (PBI). The effects of thyroidal status, the presence or absence of goiter or cardiac disease, and the patient's age, sex and menstrual status have been examined, enabling statistical diagnostic limits to be set for each test for the different categories of patients. Precise diagnosis can be achieved with an early I131 clearance test, combined with PBI and triiodothyronine suppression in some cases. About 1.6 tests per patient, in those unaffected by medication, should allow only minimal diagnostic errors. The uptake rates for euthyroid subjects in Arkansas are about one third the values found in Australia. Hyperthyroid patients have about the same range in both places.—Bernard Loitman, M.D.

Corey, K. R., Kenny, P., Greenberg, E., and Laughlin, J. S. Detection of bone metastases in scanning studies with calcium-47 and strontium-85. J. Nuclear Med., Nov., 1962, 3, 454–471. (From: Divisions of Biophysics and Clinical Investigation, the Sloan-Kettering Institute for Cancer Research, and Memorial Hospital for Cancer and Allied Diseases, New York, N. Y.)

The authors have applied the HEG scanner to the diagnosis of bone metastases from breast carcinoma which were not revealed by the usual roentgenographic examinations. The HEG scanner was designed specifically for external counting of high energy gamma radiation as from Ca<sup>47</sup> and Sr<sup>85</sup> (1.8 mev. and 0.5 mev., respectively). The scanning technique is described in detail. The results of studies on 6 patients who had been injected intravenously with Ca<sup>47</sup> or Sr<sup>85</sup> are given in graphs, roentgenograms or scans, and tables.

In 4 patients no evidence of bone metastases could be found by the roentgenographic or isotope studies. However, a slight to moderate increase in isotope uptake was noted between the fifth and ninth thoracic vertebrae.

Two patients had localized bone pain with negatively reported roentgenograms. Elevated uptakes over the pain areas indicated bone lesions which subsequently were proven at surgery and later by roentgenographic examination.

The authors conclude that the HEG scanning system with its quantitative read-out has advanced

the possibility of detecting and outlining bone lesions, and also allows one to study more precisely the calcium turnover in the lesions.—James M. Bader, M.D.

CAVALIERI, RALPH R., and KING, E. RICHARD. The use of iodine-132 to study thyroid function following therapy with iodine-131. J. Nuclear Med., Nov., 1962, 3, 436–444. (From: The Radioisotope Laboratory and Radiation Exposure Evaluation Laboratory, U. S. Naval Hospital, National Naval Medical Center, Bethesda, Md.)

A method of measuring thyroid function shortly after I<sup>131</sup> therapy would be desirable to help predict the clinical response to therapy. The method might also be used to study the mechanism of radiation-induced changes in thyroid function.

The authors describe a method with  $I^{132}$  utilizing the significant pulse height spectra differences between  $I^{131}$  and  $I^{132}$ . Twenty-nine per cent of the gamma rays of  $I^{132}$  have an energy greater than 1 mev., while  $I^{131}$  does not emit gamma radiation of this intensity. Due to the higher energy levels of  $I^{132}$  more shielding is necessary in the collimator. The short half life of  $I^{132}$  (2.3 hours) allows repeated tests with little additional radiation exposure to the thyroid and essentially no contamination for subsequent tests.

The response to therapy I<sup>131</sup> was hyperfunctioning thyroid glands, as early as one week after therapy. The authors were able to ascertain the success or failure of treatment well in advance of the clinical response. They also used the thiocyanate release tests and suggested that the early effect of radiation was on the iodide trapping mechanism rather than the organification of the trapped iodide.—James M. Bader, M.D.

EDWARDS, TED L., JR., CLASON, W. PAGE C., and REINFRANK, RALPH F. Renal excretion of Co<sup>57</sup> B<sub>12</sub> in renal disease. *Am. J. M. Sc.*, Nov., 1962, 244, 587–592. (From: The Department of Medicine, Hartford Hospital, Hartford, and the Veterans Administration Hospital, Newington, Conn.)

The Schilling test is a method of demonstrating gastrointestinal absorption of radioactive vitamin  $B_{12}$ . Interpretation of the test assumes normal renal function, complete collection of all urine during the 24 hour test period, and lack of significant binding of the radioactive  $B_{12}$  to tissues or plasma proteins.

Previous studies have demonstrated Schilling test results diagnostic of pernicious anemia in patients with renal disease. It was suggested that the low urinary excretion rates of radioactive  $B_{12}$  were due to impaired glomerular filtration. The reduced excretion rates paralleled the reduction in endogenous crea-

tinine clearance and elevation of the blood urea nitrogen.

The authors measured urinary excretion rates of  $Co^{57}$   $B_{12}$  in three groups of patients: normal patients, non-azotemic patients with renal disease, and azotemic patients. They describe the method, and the data from 16 patients in the study are presented by tables and graphs. Comparison of the urinary  $Co^{57}$   $B_{12}$  excretions was made with the 15 minute phenolsulphonphthalein test, creatinine clearance, and blood urea nitrogen. Good correlation was found between the  $Co^{57}$   $B_{12}$  excretions and the phenolsulphonphthalein test and the creatinine clearance. The authors advise a 72 hour urine collection. At 72 hours, the difference in the total urinary  $Co^{57}$   $B_{12}$  excretion between renal disease patients and normal patients was found to be less apparent than at 24 hours.

In conclusion, the authors state that the use of the 15 minute phenolsulphonphthalein test is a reliable measure of renal ability to excrete vitamin  $B_{12}$ . If the phenolsulphonphthalein values exceed 20 per cent, the Schilling test may be employed in the usual manner.— James M. Bader, M.D.

Weijer, D. L., Duggan, H. E., and Scott, D. B. Excretion of P<sup>32</sup> after therapy for polycythemia rubra vera. *J. Canad. A. Radiologists*, Sept., 1962, 13, 81–85. (From: University Hospital, Edmonton, Alberta, Canada.)

Excretion of P<sup>32</sup> in both urine and feces in patients with polycythemia rubra vera has not been very extensively studied in the past. It is probable that most of the administration of P<sup>32</sup> has been associated with a carrier, and there has not been constancy concerning fasting before the administration of the dose. It was felt that both the amount of carrier added to the P<sup>32</sup> (oral or intravenous administration) as well as the fasting or nonfasting condition of the patient would affect the excretion rates. It has been assumed that when P<sup>32</sup> is used orally the dose should be increased by a factor of 4/3 to compensate for the 25 per cent to 33 per cent of the dose not absorbed by the gastrointestinal tract. This figure is based upon a few tracer studies in normal persons.

Seventeen patients (15 cases of polycythemia rubra vera) were given radioactive phosphorus and total excretion studies were carried out for each case. In 11 cases, the carrier-free  $P^{32}$  was administered intravenously and in 6 cases by mouth. Of the latter, 5 cases were fasting. Total excretion of  $P^{32}$  does not differ significantly for oral and intravenous administration and, therefore, it appears that under fasting conditions, it is not necessary to increase the oral dose of  $P^{32}$  to 4/3 of the intravenous dose in order to obtain an equivalent absorption. It should be possi-

ble to administer the same therapeutic dose of P<sup>32</sup> either orally or intravenously to obtain the same clinical effect.—*Lois Cowan Collins*, *M.D.* 

CHIAPPA, S., GALLI, G., BARBAINI, S., and RAVASI, G. La radioterapia endolinfatica: primi risultati di una nuova metodica. (Endolymphatic radiotherapy: first results of a new procedure.) *Radiol. med.*, July, 1962, 48, 663–692. (Address: Dr. S. Chiappa, Via Tabacchi 52, Milano, Italy.)

The technique is based on the method of lymphography described by Kinmonth. The contrast medium used is lipiodol "F" tagged with I<sup>131</sup>.

The liposoluble contrast medium tagged with I<sup>131</sup> is injected through one of the lymphatics of the dorsal aspect of the foot. It reaches the inguinal, the common iliac and the lumbar and aortic lymph nodes, where it remains for a long time. The radiopaque lymph nodes can be demonstrated from 4 to 6 months after the injection of the contrast medium.

In most cases the lipiodol "F"-I<sup>131</sup> is introduced in one foot only, and the same amount of simple lipiodol "F" is injected in the other foot.

The studies were carried out in 4 cases of Hodg-kin's disease, 3 cases of lymphosarcoma and 1 case each of aleukemic lymphadenosis, metastatic involvement of the lymph nodes by an adenocarcinoma of the rectum, and reticulum cell sarcoma.

In a first series of 10 cases, 200–500 µc were injected, not for therapeutic purposes but to study the distribution of the contrast medium and its gradual elimination from the organism. In a second group of 10 patients, 8, 10 and 12 mc were introduced without any secondary reaction.

The effects of lipiodol "F"-I<sup>131</sup> on the lymph nodes were repeatedly evaluated, at first 8, 15 and 30 days after injection, and thereafter every month.

An analysis of the results shows that the therapeutic effects are evident, in the most radiosensitive forms, already during the first week. The dosage of 8–12 mc results in faster regression of the lymph node involvement, when compared to similar cases treated by chemotherapeutic agents.

Furthermore, the opacification of the lymph nodes permits a direct evaluation of the degree and extension of the lymphatic involvement and consequently the changes following the injection of the radioactive contrast medium.

The limitations of this procedure are mainly the restricted area of the lymphatic chain, which can be treated, and that in a lymph node totally replaced by neoplastic tissue there is no or there is only poor uptake of the radioactive substance.

The indications for endolymphatic radiotherapy are at the moment limited and a larger number of cases should be treated in order to obtain more definite conclusions.—A. F. Govoni, M.D.

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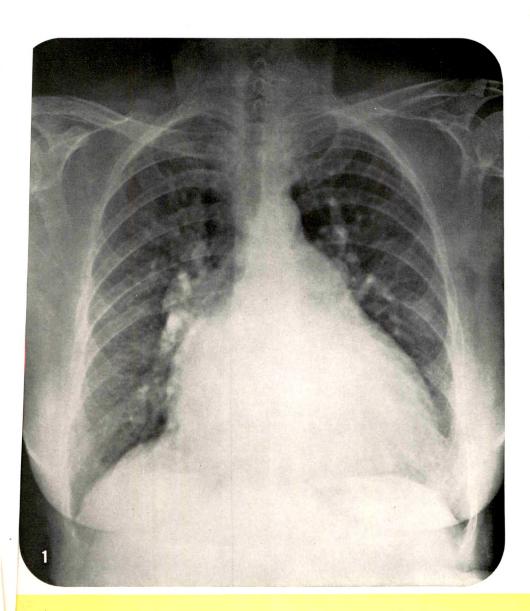
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Patient had history of acute rheumatic fever at age of 6 years. Had not worked for 2 years prior to operation because of palpitations and easy fatigability.

On physical examination, there was a systolic murmur along the left sternal border and electrocardiogram showed  $P_2$  to be widely split.

Radiograph (Figure 1) revealed enlargement of the heart with dilatation of the main pulmonary artery and increased pulmonary vascularity.

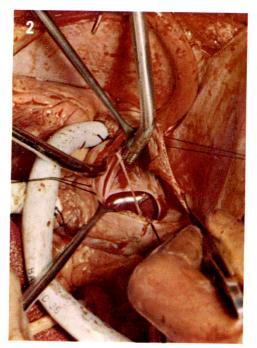
Cardiac catheterization showed a left-to-right shunt at the atrial level with a pulmonic blood flow 3.4 times the systemic blood flow.

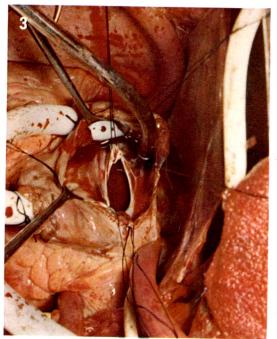
At open heart surgery (Figures 2 and 3) a 3.5 by 4-cm atrial septal defect was closed. Patient has done well since operation.

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**Figure 2.** Atriotomy showing ostium secundum type of atrial septal defect.

**Figure 3.** Defect with sutures at each end.



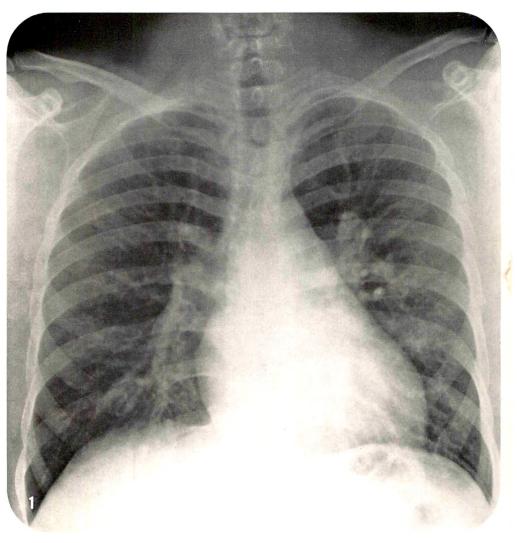


FOR DETAILS OF CASE TWO-TURN PAGE

## Congenital Heart Disease: (Atrial Septal Defect

Two cases—each with radiograph and color photographs of surgical correction

CASE ONE: Atrial septal defect in man 28 years old



**Figure 1.** Preoperative radiograph, posteroanterior projection. Note enlargement of heart with dilatation of the main pulmonary artery.

# CASE TWO: Atrial septal defect and correction in 63-year-old married woman

Patient was well until age 45 when she developed dyspnea upon exertion. There was a gradual progression of symptoms, including easy fatigability, dizzy spells and substernal pain. Also a systolic murmur at the base and the apex of the heart.

The electrocardiogram showed incomplete right bundle branch block.

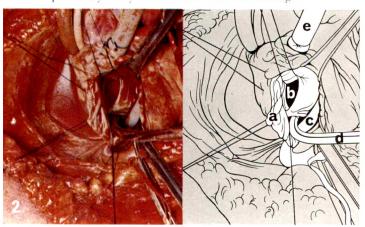
Radiograph (Figure 1) showed an increase in size of all chambers of the heart, enlargement

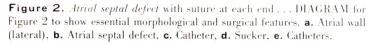
of the main pulmonary artery and increased vascular markings.

Cardiac catheterization demonstrated a left-toright shunt of 17.8 liters per minute at the atrial level with a right ventricular pressure of 155/11 mm Hg.

At open heart surgery, a 2 by 3-cm atrial septal defect was successfully closed (Figures 2 and 3). General condition has greatly improved since surgery.

Figure 1. Preoperative radiograph: Note enlargement of heart and main pulmonary artery with increased vascular markings.





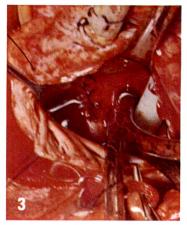


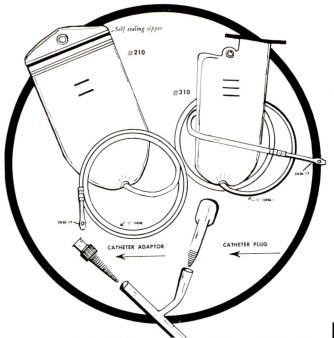
Figure 3. Defect closed with interrupted sutures.

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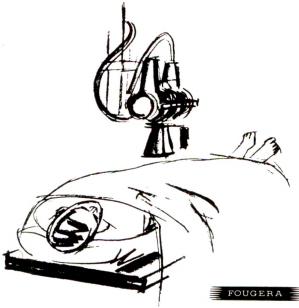
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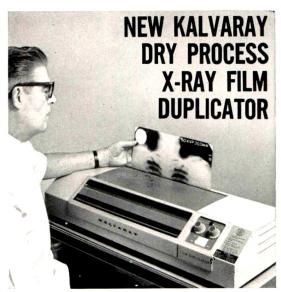
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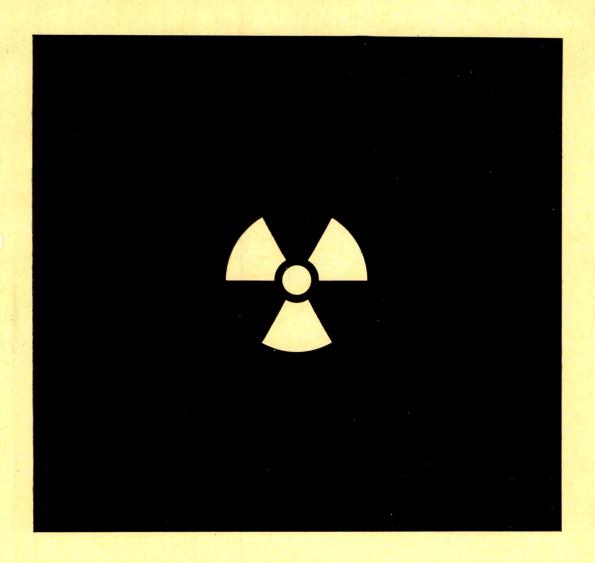
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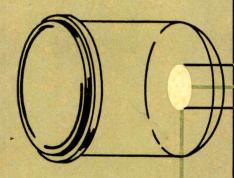
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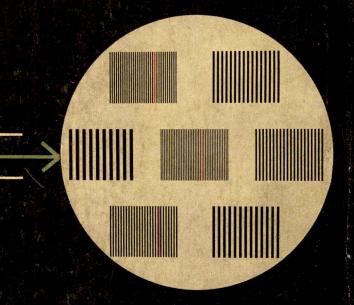


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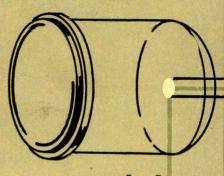
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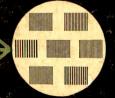


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